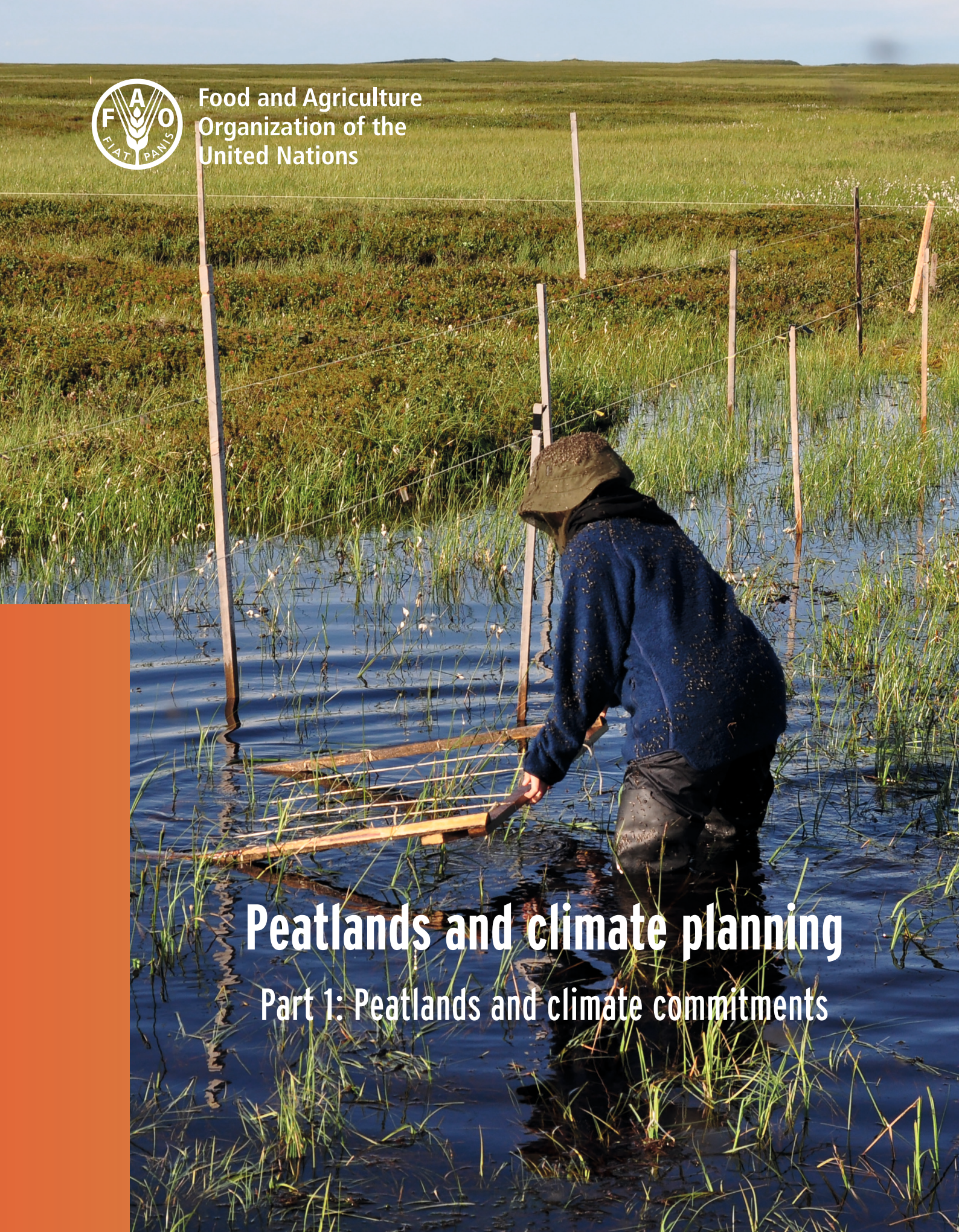


Food and Agriculture Organization of the United Nations

Peatlands and climate planning

Part 1: Peatlands and climate commitments

SHOUT
SHARE
IT

Peatlands and climate planning

Part 1: Peatlands and climate commitments

Food and Agriculture Organization of the United Nations
Rome, 2022

Required citation:
FAO. 2022. Peatlands and climate planning - *Part 1: Peatlands and climate commitments.* Rome. https://doi.org/10.4060/cc2895en

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement. The mention of specific companies or products of manufacturers,whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

The views expressed in this information product are those of the author(s) and do not necessarily reflect the views or policies of FAO.

ISBN 978-92-5-137182-4

© FAO, 2022

Some rights reserved. This work is made available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; https://creativecommons.org/licenses/by-nc-sa/3.0/igo/legalcode).

Under the terms of this licence, this work may be copied, redistributed and adapted for non-commercial purposes, provided that the work is appropriately cited. In any use of this work, there should be no suggestion that FAO endorses any specific organization, products or services. The use of the FAO logo is not permitted. If the work is adapted, then it must be licensed under the same or equivalent Creative Commons licence. If a translation of this work is created, it must include the following disclaimer along with the required citation: "This translation was not created by the Food and Agriculture Organization of the United Nations (FAO). FAO is not responsible for the content or accuracy of this translation. The original [Language] edition shall be the authoritative edition."

Disputes arising under the licence that cannot be settled amicably will be resolved by mediation and arbitration as described in Article 8 of the licence except as otherwise provided herein. The applicable mediation rules will be the mediation rules of the World Intellectual Property Organization http://www.wipo.int/amc/en/mediation/rules and any arbitration will be conducted in accordance with the Arbitration Rules of the United Nations Commission on International Trade Law (UNCITRAL).

Third-party materials. Users wishing to reuse material from this work that is attributed to a third party, such as tables, figures or images, are responsible for determining whether permission is needed for that reuse and for obtaining permission from the copyright holder. The risk of claims resulting from infringement of any third-party-owned component in the work rests solely with the user.

Sales, rights and licensing. FAO information products are available on the FAO website (www.fao.org/publications) and can be purchased through publications-sales@fao.org. Requests for commercial use should be submitted via: www.fao.org/contact-us/licence-request. Queries regarding rights and licensing should be submitted to: copyright@fao.org.

COVER PHOTOGRAPH © Hans Joosten, Greifswald Mire Centre. 2011. Polygon mire in Yakutia, Northeast Siberia.

Contents

About this report vi

Acknowledgements viii

Abbreviations and acronyms ix

Executive summary x

1. Introduction 2

2. Peatlands' contribution to climate action 8

2.1. Fragility, uniqueness and emission reductions 11

2.2. Climate change adaptation 12

2.3. Drivers of change 16

3. Enhancing climate action 20

3.1. The commitment process 20

3.2. Current inclusion of peatlands in climate commitments 26

3.3. Good practices 30

3.4. The transparency framework 30

3.5. Key peatland opportunities 35

3.6. Tools to support integration 42

3.7. Financing peatland action 42

4. Conclusions 50

References 52

Boxes

Box 1	The many peatland typologies	12
Box 2	Indonesia's mid-term climate contributions and peatland restoration	15
Box 3	The Democratic Republic of the Congo and its commitments	22
Box 4	Indonesia's Long-Term Strategy	24
Box 5	Fire-care community groups in Indonesia	35
Box 6	Paludiculture and examples in Southeast Asia	40

Figures

Figures 1	Global peatland map	3
Figures 2	Global goals and commitments where peatlands contribute	9
Figures 3	Important peatland interrelations: peatland components	10
Figures 4	Important peatland interrelations: ecosystem services	10
Figures 5	Important peatland interrelations: contributions to Sustainable Development Goals	10
Figures 6	Soaking wet peat with *Sphagnum* moss vegetation on top	11
Figures 7	Environmental and social impacts of peatland drainage	13
Figures 8	Examples of major drivers of peatland drainage and degradation	16
Figures 9	Global GHG emissions of modelled pathways	21
Figures 10	Forest and land use sector emission projections in Indonesia	24
Figures 11	Regional distribution of NDCs that have mentioned peatlands (submitted between 2015 and 23 September 2022)	29
Figures 12	Percentage of NDCs that have mentioned different types of wetlands (submitted between 2015 and 23 September 2022)	29
Figures 13	Moving from measurement, reporting and verification towards the transparency framework	31
Figures 14	Data needed for monitoring drained peatlands	33
Figures 15	Example to identify principles, criteria and indicators for peatland restoration	34
Figures 16	Representation of a tropical peat dome	36
Figures 17	Landscape of the Torronsuo national park	37
Figures 18	Approach to peatland restoration	38
Figures 19	Principles of sustainable food value chain development	41

Tables

Table 1	Action options for climate commitments	4
Table 2	Full rewetting helping to solve problems associated with peatland drainage	14
Table 3	Areas covered by improved peatland and water management and peatland restoration in Indonesia	25
Table 4	Sub-Saharan Africa: Examples of peatland measures	26
Table 5	Asia and the Pacific: Examples of peatland measures	27
Table 6	Europe and Central Asia: Examples of peatland measures	27
Table 7	Latin America, the Caribbean and Northern America: Examples of peatland measures	28
Table 8	Domestic financing sources for climate action on peatlands	44
Table 9	Examples of international financing sources for climate action on peatlands	45

About this report

This report is part of Global Peatlands Initiative's work, with FAO's lead, to support national governments in the process of enhancing nationally determined contributions (NDCs) through the inclusion of climate action on peatlands. The package of products under a series entitled "Peatlands and climate commitments" aims to inform key stakeholders on practical and applicable means to protect, restore and sustainably manage peatlands. The authors aim to motivate national agencies to include peatland considerations into national legislative, regulatory, planning and monitoring processes in order to ensure their implementation.

Key target audience

This report may especially benefit entities involved in the formulation, updating, refinement, implementation and monitoring of NDCs and other climate-related policies that can have a direct or indirect impact on peatland landscapes. It targets entities in charge of peatland management and decision-making in particular at the national level but also supports action at provincial and local levels.

These entities include a large spectrum of sectors and areas of work, such as agriculture, land and water management, environment, forestry, infrastructure, socioeconomic development, energy and extractive industries, disaster risk reduction, and monitoring systems. Case studies illustrate how countries have addressed peatland-related climate change adaptation and mitigation actions.

Acknowledgements

Chapter authors and other contributors

Chapter 1. Introduction: Elisabet Rams Beltrán, Maria Nuutinen and Hans Joosten

Chapter 2. Peatlands' contribution to climate action: Hans Joosten, Maria Nuutinen and Elisabet Rams Beltrán

Chapter 3. Enhancing climate action: Laura Villegas Mejia, Elisabet Rams Beltrán, Marggiori Pancorbo Olivera, Rocío Dánica Cóndor Golec, Hans Joosten, Daniel Murdiyarso, Maria Nuutinen, Eva Ntara, Peter Moore, Laure-Sophie Schiettecatte, Krystal Crumpler, Martial Bernoux, Daniel Dionisio and Samer Elshehawi

Chapter 4. Conclusions: Elisabet Rams Beltrán, Maria Nuutinen, Hans Joosten

FAO is ever so grateful to the excellent collaboration with Professor Hans Joosten from the Greifswald Mire Centre, Germany, and Professor Daniel Murdiyarso from the Centre for International Forest Research (CIFOR) and as well as collaborators and reviewers in the partner organizations.

Collaborators in the definition of this publication, and the entire series of the reports "Peatlands and climate commitments" include Jerker Tamelander from the Ramsar Convention on Wetlands, Jan Peters from the Greifswald Mire Centre, Sri Parwati Murwani Budisusanti from the Indonesian Ministry of Environment and Forestry, Jean-Jacques Bambuta from the Ministry of Environment and Sustainable Development of the Democratic Republic of the Congo, Hans Schutten and Tatiana Minayeva from Wetlands International, Dianna Kopansky and Julie Van Offelen from the United Nations Environment Programme (UNEP), Rupesh Bhomia and Denis Sonwa from CIFOR, Erik Lilleskov from US Forest Services, as well as, colleagues from FAO, including Adam Gerrand, Rocío Dánica Cóndor Golec, María Ruiz Villar, Till Neeff, and Martial Bernoux.

The report has been **contextualized and reviewed** by experts from the Ramsar Convention on Wetlands Secretariat, UNEP and UNEP-WCMC, CIFOR, Greifswald Mire Centre and the Michael Succow Foundation, Wetlands International, and the US Forest Services, as well as Amy Duchelle and Tiina Vähänen from FAO.

The core FAO team contributing to the inception, writing and editing includes Maria Nuutinen, Elisabet Rams Beltrán, Lucy Garrett, Laura Villegas Mejia, Marggiori Pancorbo and Eva Ntara. The design and layout were completed by Constance de Williencourt and with the original concept by Lorenzo Catena. The NDC analysis was conducted in close collaboration with and under the leadership of FAO's Office of Climate Change, Biodiversity and Environment (OCB) with Laure-Sophie Schiettecatte, Krystal Crumpler, Daniel Dionisio, under guidance of Martial Bernoux; and in collaboration with Samer Elshehawi and Hans Joosten from Greifswald Mire Centre.

FAO extends its gratitude to the German International Climate Initiative, IKI, as this report is part of the project activities under the Global Peatlands Initiative project, as well as the project partners, UNEP and the Greifswald Mire Centre.

Christine Legault and the Publications Branch (OCCP) in FAO's Office of Communications (OCC) provided editorial support.

Abbreviations and acronyms

AFOLU	agriculture, forestry and other land use
BAU	business-as-usual
CBIT	Capacity Building Initiative for Transparency
CIFOR	Centre for International Forestry Research
CO_2	carbon dioxide
ETF	Enhanced Transparency Framework under the UNFCCC process
FAO	Food and Agriculture Organization of the United Nations
GHG	greenhouse gas
GMC	Greifswald Mire Centre
IKI	the International Climate Initiative of Germany
IPCC	Intergovernmental Panel on Climate Change
LTS	long-term low greenhouse gas emission development strategies under the UNFCCC
MRV	monitoring reporting and verification
Mt	Megatonne(s), i.e. 1 million tonnes
NAMA	nationally appropriate mitigation action (within the UNFCCC process)
NDC	nationally determined contribution under the UNFCCC process
NFMS	national forest monitoring system
N_2O	nitrous oxide
RBP	results-based payments
REDD+	Reducing Emissions from Deforestation and Forest Degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
SDG	Sustainable Development Goal
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

Executive summary

To reach climate neutrality by 2050, the greenhouse gas emissions from degrading and/or burning peatlands must be stopped by **rewetting degraded peatlands and conserving healthy ones.** This report sets out the **key elements** that countries can consider related to peatland protection, restoration and sustainable management when **enhancing their climate commitments**.

Peatlands are **present in at least 178 countries**. These lands **contain huge carbon stocks** in the peat soil – almost twice the carbon stock of the total biomass of the world's forests. Although they cover only 3–4 percent of the world's land surface, peatlands provide diverse ecosystem services. The provision of food, feed and fibre, their carbon storage and sink capacity, as well as freshwater regulation, shelter and employment opportunities can help **support the achievement of climate and development goals.**

An estimated **11–15 percent of peatlands have been drained and otherwise degraded** mainly for crop and grazing land, forestry, energy and infrastructure, contributing to almost 5 percent of all global anthropogenic greenhouse gas emissions. Other **potential impacts of peatland degradation** include land subsidence, saltwater intrusion, loss of productivity, and loss of biodiversity.

Still, as of September 2022, less than 15 percent of countries with known peatlands include them in their nationally determined contributions to the Paris Agreement. Our analysis of peatland-related contributions presented in this report highlights that countries can approach climate action through peatlands in different ways, and several lessons emerge. First, peatlands should be mapped and monitored, since otherwise they are lands without apparent value, and their management requirements are often ignored during land use planning processes. Second, more finance is needed. Even if peatland action is among the most cost-effective ways of reducing greenhouse gas emissions, there is a widespread underinvestment in improving peatland management. Domestic and international sources of finance can be leveraged, including through increased taxes on activities that damage peatlands, investment in zero-drainage supply chains, and payments for ecosystem services, among others. Third, meaningful stakeholder engagement – especially with local communities – can support the design and implementation of policies and actions that affect peatlands and local livelihoods.

Humanity still has an opportunity to turn the tide, by ensuring that all peatlands are wet by 2050. The **goals of the Paris Agreement cannot be reached without peatlands**.

***Keywords**: peatlands; peat; organic soils; wetland; climate action; climate change; Paris Agreement; nationally determined contributions; long-term strategies; enhanced ambition; nature-based solutions; ecosystem restoration; greenhouse gas; avoided emissions; reporting; monitoring; Global Peatlands Initiative; transparency; UN Framework Convention on Climate Change; Sustainable Development Goals*

© Greifswald Mire Centre/H. Joosten

Chapter 1

Introduction

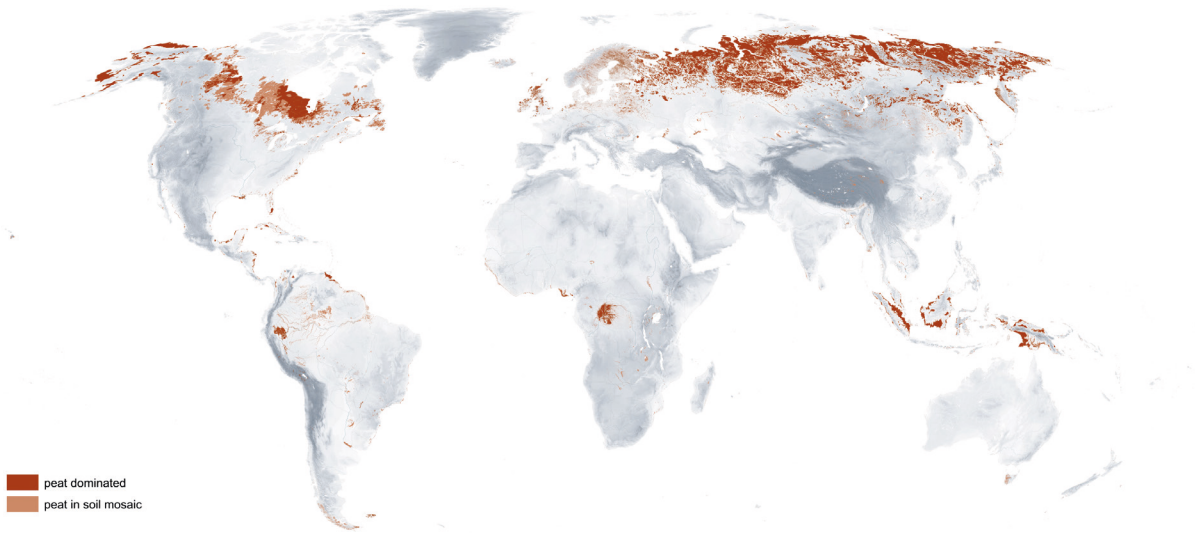
© Greifswald Mire Centre/H. Joosten

Chapter 1

Introduction

Why integrate peatlands in national climate action and contributions? Peatlands contain huge carbon stocks in their peat soil – almost twice the carbon stock of the total biomass of the world's forests and as much as all the carbon in the atmosphere in 2014 (Turetsky *et al.*, 2015) – yet cover only 3 percent of the world's land area across at least 178 countries (Figure 1). Peatland conservation and restoration provide an invaluable mitigation opportunity to maintain this carbon stock and avoid its contribution to global heating. Improved peatland management also secures ecosystem services that support adaptation to climate change. Including peatlands under agriculture, forestry and other land use (AFOLU) sector, as well as the energy sector's emission reduction targets, offers an often overlooked contribution for countries to reach goals set under the Paris Agreement.

Figure 1 Global peatland map



Disclaimer: The boundaries and names shown and the designations used on these map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries.

Note: See the latest updated map in the sources.

Sources: Peatland data: **Greifswald Mire Centre**. 2021. Global Peatland Database. In: *Greifswald Mire Centre* Greifswald, Germany. Cited 30 August 2022. https://greifswaldmoor.de/global-peatland-database-en.html
UNEP. (forthcoming). *Global Peatlands Assessment: The State of the World's Peatlands. Evidence for action toward the conservation, restoration, and sustainable management of peatlands. Main report.* Nairobi.
Elevation data: **Jarvis, A., Reuter, H.J., Nelson, A. & Guevara, E.** 2008. Hole-filled SRTM for the globe. Version 4. In: *CGIAR-CSI SRTM 90M database*. CGIAR Consortium for Spatial Information. Cited 11 November 2022. https://srtm.csi.cgiar.org/
Boundaries: **United Nations Geospatial**. 2020. *Map of the World. Cited 11 November 2022.* www.un.org/geospatial/file/3420/download?token=TUP4yDmF
Water: Water: Natural Earth. 2022. Physical vector data version 4.1.0. In: *Natural Earth*. Cited 11 November 2022. www.naturalearthdata.com

Peatlands' strong interrelation between water, plants and peat supports the provision of many other vital ecosystem services. Wet, undrained peatlands provide water security for communities and cities, support food security, reduce risk of fires, floods and droughts, enable cooling of the landscape and also contribute to ecological resilience under climate-related disasters. In wet (pristine) and rewetted state, peatlands allow sustainable biomass production, called "paludiculture", to support livelihoods.

Table 1 **Action options for climate commitments**

Actions	Potential benefits: the estimated intensity is indicated with the number of "+"				
	Action readiness	Emission reduction and/or avoidance	Adaptation and resilience	Co-benefits	Potential to access current climate finance
Mapping	+++				
Inventory or assessment	+++				
Land use planning to avoid peatland impacts		+ + +	+ + +	+ + +	+ + +
Conservation target setting		+ + +	+ +	+ + +	+
Harmonization of regulatory frameworks, policies and incentives to avoid conversion		+ + +	+ +	+ + +	+
Strengthening law enforcement		+ +	+ +	+	
Setting restoration targets		+ +	+ +	+ +	+ + +
Restoration for coastal protection		+ + +	+ + +	+ + +	+ + +
Prohibition of peatland clearance with fire		+ + +	+ + +	+ + +	+ + +
Transitioning from drainage-based to wet peatland management: crop & grazing land, forestry, energy, and others		+ + +	+ +	+ + +	+ + +
Development of sustainable livelihood options in wet peatland landscapes		+ + +	+ + +	+ + +	+
Assessment of greenhouse gas and/or adaptation benefits	+++				+++
Integration into land use monitoring systems	+++				+++
Implementing a fire-danger rating system, or other early-warning, early-action systems	+++				++

Globally, around 15 percent of peatlands have been drained, mainly for agriculture and forestry (IUCN, 2017). This drained area contributes to almost 5 percent of all global anthropogenic greenhouse gas emissions (Gewin, 2020). Other potential impacts of peatland drainage include land subsidence, loss of productivity, saltwater intrusion and loss of biodiversity. To reach the Paris Agreement goals to mitigate and adapt to climate change, drained peatlands must be largely restored and rewetted and the remaining healthy peatlands conserved and protected. To achieve their climate mitigation and adaptation potential, it is necessary that peatlands are mapped and monitored to show their value, although these processes do not need to be completed before initiating improvements in management.

This report is the first of three products under the series on "Peatlands and climate commitments" with contributions from Global Peatlands Initiative members and focuses on the planning phase of climate commitments. The second product will focus on the implementation phase, and the third will present more detailed results of an analysis on how wetlands and organic soils are included in current climate commitments and the opportunities they offer to countries.

Enhancing climate action through peatlands

Peatlands are particularly fragile due to their hydrological interconnections. GHG emissions from drained and degraded peatlands continue for decades unless they are restored and rewetted or their peat carbon stock is completely depleted.

Broad and transparent stakeholder consultations and close collaboration with experts at the onset of the planning phase are key to ensure socially-just and science-based climate commitments and implementation of actions. Furthermore, robust and holistic peatland monitoring supports adaptive management, helps to justify investment, and, when complemented by early warning of hazards, can help avoid peatland loss by early-action. Table 1. Action options for climate commitments summarizes the action options for climate commitments and their potential, estimated benefits for capacity development and readiness, GHG emission reductions and/or avoidance, climate adaptation and resilience, mitigation and adaptation co-benefits and the potential to access current climate finance sources. A higher number of plusses (+) indicates more benefits.

This report sets out the key elements that countries need to consider and refers to relevant knowledge resources and guiding tools to integrate peatlands into climate action. Hyperlinks and the list of references offer the reader ample sources for further information and guidance. Key opportunities of improved management, including conservation, restoration, monitoring and sustainable livelihoods, are briefly explained and exemplified. Finally, some financing options both from national as well as from international and private sources are also illustrated when considering feasibility for implementation.

© Greifswald Mire Centre/H. Joosten

Chapter 2

Peatlands' contribution to climate action

© Greifswald Mire Centre/H. Joosten

Chapter 2

Peatlands' contribution to climate action

Peatlands provide diverse ecosystem services including the provision of food, feed and fibre, as well as freshwater, shelter and employment. Healthy, wet peatlands can ensure the provision of most of these benefits in the long term, promoting ecosystem and socioeconomic resilience. Peatlands are and will continue to undergo many changes and challenges as a result of climate change. Their conservation, restoration and sustainable management will have to adapt to meet these changing dynamics.

© Convention on Wetlands/Andreas Raukas

Figure 2 **Global goals and commitments where peatlands contribute**

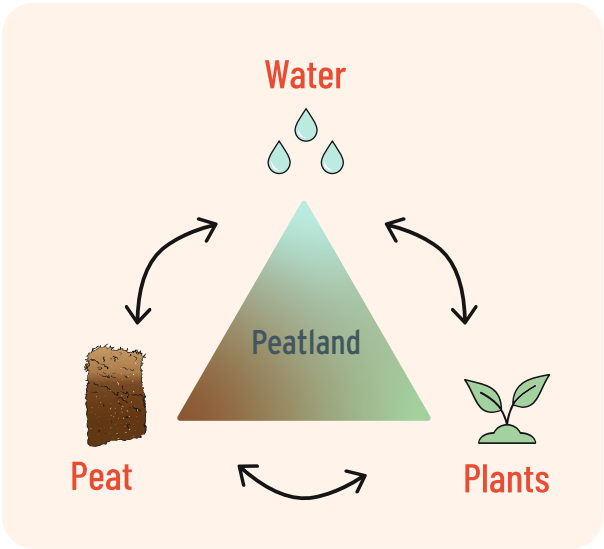
To address current and upcoming challenges, the international community has formulated ambitious goals, most importantly the United Nations Sustainable Development Goals (SDGs), the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC); the Ramsar Convention on Wetlands resolutions, such as Resolution XII.11 on Peatlands, climate change and wise use, and Resolution VIII.17 on Guidelines for Global Action on Peatlands; the post-2020 Global Biodiversity Framework under the United Nations Convention on Biological Diversity (CBD); land degradation neutrality (LDN) under the United Nations Convention to Combat Desertification (UNCCD) and the resolution on climate change and migratory species under the Convention on Migratory Species (CMS). Similarly, the United Nations Environment Assembly (UNEA) 2019 resolution on Conservation and Sustainable Management of Peatlands and the UN Decade on Ecosystem Restoration requested by the UNEA members (March, 2019) underline special action for peatlands. In addition, other restoration commitments, such as the Bonn Challenge for forest, peatland and landscape restoration, together with many regional, national and local initiatives targeting conservation, restoration and improved management (Figure 2) are encouraging action (for more, see also, FAO, 2020).

In the near future, peatlands will undergo many changes and challenges as a result of climate change. Their conservation, restoration and sustainable management will have to adapt to meet these changing dynamics.

The Paris Agreement has set concrete goals to address the overarching challenge of climate change, specifically "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels". The Intergovernmental Panel for Climate Change (IPCC, 2018) has translated the latter goal into quantified emission reduction targets with transformational pathways reaching 50 percent GHGs emission reduction by 2030 and net zero by 2050.

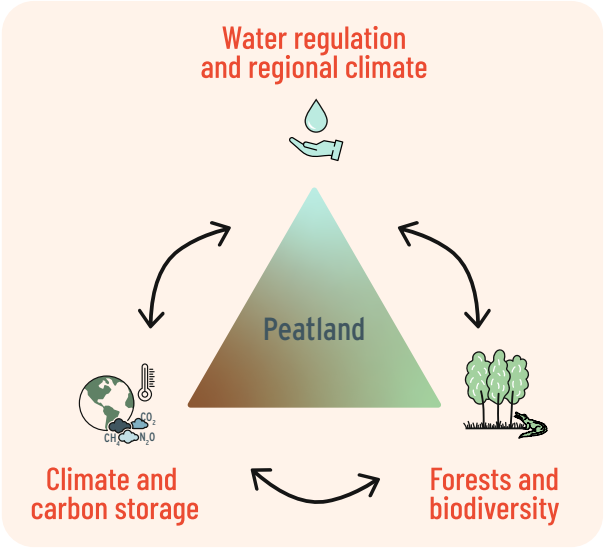
The SDG 13: Climate action is veryrelevant also to peatlands. One of the targets to achieve this goal includes the integration of climate change measures into national policies, strategies and planning. The Paris Agreement established binding commitments by all Parties in a set process, where increased ambition is inbuilt in time and progress is regularly reported. Stocktaking, to begin in 2023, will allow the global community to check if the level of climate action is sufficient to achieve the agreed goal. Mid-term commitments are and will be included in domestic measures submitted as nationally determined contributions (NDCs), and long-term low greenhouse gas emission development strategies - also referred to as the long-term strategies (LTS).

Figure 3 **Important peatland interrelations: peatland components**



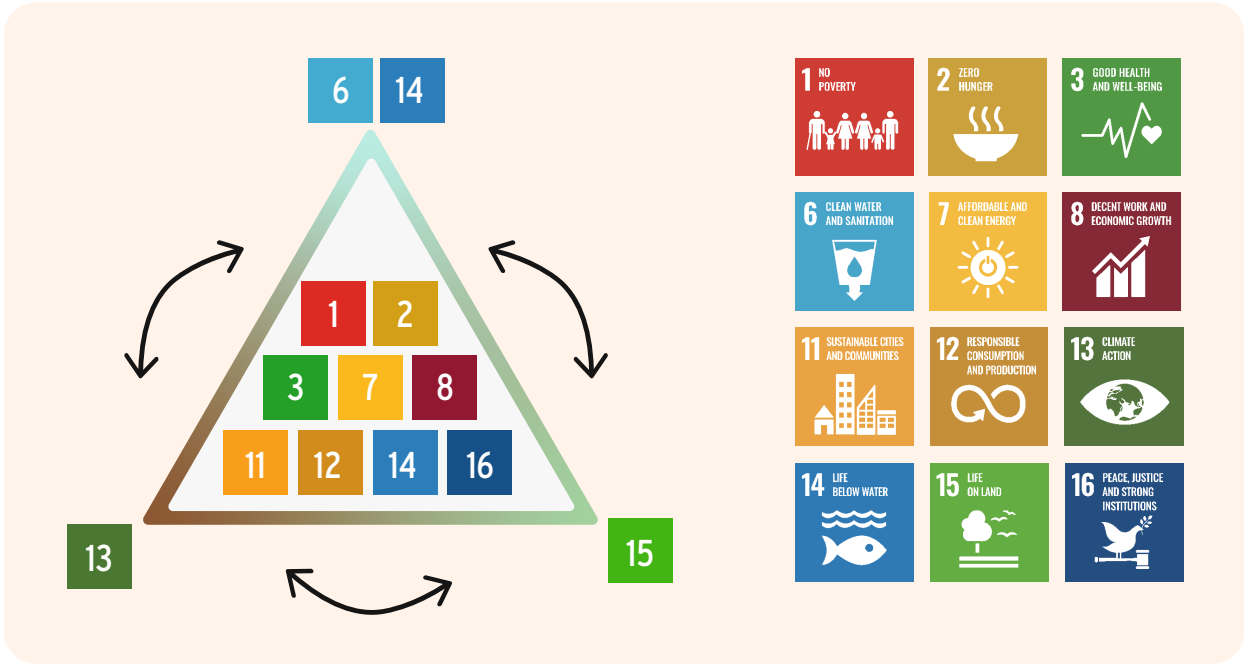
Source: Modified after **Joosten, H.** 2016. Peatlands across the globe. In: A., Bonn, T., Allott, M., Evans, H., Joosten & R., Stoneman, eds. *Peatland restoration and ecosystem services: Science, policy and practice.* pp. 17-43. Cambridge, UK, Cambridge University Press and British Ecological Society.

Figure 4 **Important peatland interrelations: ecosystem services**



Source: Modified after **Joosten, H.** 2016. Peatlands across the globe. In: A., Bonn, T., Allott, M., Evans, H., Joosten & R., Stoneman, eds. *Peatland restoration and ecosystem services: Science, policy and practice.* pp. 17-43. Cambridge, UK, Cambridge University Press and British Ecological Society.

Figure 5 **Important peatland interrelations: contributions to Sustainable Development Goals**



Source: Modified after **Joosten, H.** 2016. Peatlands across the globe. In: A., Bonn, T., Allott, M., Evans, H., Joosten & R., Stoneman, eds. *Peatland restoration and ecosystem services: Science, policy and practice.* pp. 17-43. Cambridge, UK, Cambridge University Press and British Ecological Society.

Peatlands hold huge but fragile carbon stocks, which can easily be mobilized through changes in hydrology, making degraded peatlands substantial sources of greenhouse gas (GHG) emissions. In contrast, natural, wet peatlands can contribute to the carbon sink capacity needed to reach global climate targets (Strack *et al.*, 2022).

Beyond climate change mitigation, peatlands' strong interrelation between water, plants and peat (Figure 3) supports the provision of many other strategic ecosystem services (Figure 4). These contribute to numerous SDGs, including those vital for climate change adaptation (Figure 5). Peatlands also contribute to SDG 1: No poverty, SDG 2: Zero hunger, SDG 3: Good health and well-being, SDG 6: Clean water and sanitation, SDG 7: Affordable and clean energy, SDG 8: Decent work and economic growth, SDG 11: Sustainable cities and communities, SDG 12: Responsible consumption and production, SDG 13: Climate action, SDG 14: Life below water, SDG 15: Life on land, and SDG 16: Peace, justice and strong institutions (Figure 5). All these benefits make it paramount to integrate peatlands into the NDCs.

2.1 FRAGILITY, UNIQUENESS AND EMISSION REDUCTIONS

In natural peatlands, new plant material is produced faster than dead plant material decomposes. Similar to pickled vegetables, the plant remains are conserved under water in the absence of oxygen, accumulating as "peat" (Figure 6). Natural peatlands are therefore always wetlands. Only in some permafrost areas, peat may accumulate because plant material is conserved by rising permafrost. Not all wetlands are, however, peatlands. Wetlands only accumulate peat (and can then be called "mires") where water saturation is almost continuous, because the decomposition of plant material under oxic (oxygen-rich) conditions is an order of magnitude faster than its accumulation under anoxic (oxygen-free) conditions.

Peatlands are found in at least 178 countries: from Antarctica and the Arctic to the tropics, and from the lowlands up to the high mountains.

© Greifswald Mire Centre/H. Joosten

Figure 6 Soaking wet peat with *Sphagnum* moss vegetation on top

© FAO/Elisabet Rams Beltrán

Peatlands store carbon that plants have extracted from the atmosphere during photosynthesis and have converted to (initially) living and (later) dead plant material: the basis for peat. Peatlands often accumulate peat over many thousands of years, leading to layers of peat several metres thick. This persistent accumulation is made possible by positive feedback: the dead plant remains are conserved by water, then obstruct water flow, and thereby ensure water saturation and peat accumulation at increasingly higher levels (Temmink *et al.*, 2022; Couwenberg *et al.*, 2022).

As a result of thousands of years of carbon sequestration, peatlands contain a disproportionate amount of carbon compared to other ecosystems. Typically, they hold 1 000–2 000 tonnes of carbon per hectare. Comparatively, forests on mineral soils contain 140–230 tonnes (Temmink *et al.*, 2022). Peatlands cover just 3 percent (i.e. about 450 million ha) of the land area of our planet, yet contain 600 gigatonnes (i.e. 600 000 Mt) of carbon in their peat. This equates to 30 percent of all carbon in all soils of the world and almost twice the carbon stock of the world's total forest biomass (Joosten and Couwenberg, 2008; Temmink *et al.*, 2022). Due to this enormous carbon density, it is crucial to include peatlands in the NDCs, even when the area of peatlands in a country might be small.

When peatlands are drained, the penetration of oxygen into the soil leads to a constantly progressing breakdown of the peat body. The accumulated organic matter oxidizes and is emitted into the atmosphere in the form of the greenhouse gases CO_2 and nitrous oxide (N_2O), as well as methane (CH_4), especially from the drainage ditches (Peacock *et al.*

2021). The size of emissions strongly correlates with the average level of the groundwater table in the peatland (Hirano *et al.* 2014; Carlson *et al.* 2015; Jurasinski *et al.* 2016; Wakhi *et al.* 2017; Evans *et al.* 2021).

The latest estimates on GHG emissions from drained peatlands covering approximately 0.4 percent of the Earth's land area, still account for almost 5 percent of all global anthropogenic GHG emissions (Convention on Wetlands, 2021; Günther *et al.* 2020; Leifeld *et al.*, 2019; Joosten *et al.*, 2016). The latest academic estimates for GHG emissions worldwide have been compiled for the Global Peatland Assessment with the support of a wide group of peatland experts and led by UNEP under the Global Peatlands Initiative. The data and methods will be available through the updated Global Peatland Database and the Global Peatlands Assessment report on the Global Peatlands Initiative's website.

Box 1

The many peatland typologies

Peatlands are found in at least 178 countries: from Antarctica and the Arctic to the tropics, and from the lowlands up to the high mountains. The rich variety of peatlands is determined by differences in climate, water supply, nutrient and acidity levels and vegetation. Their diversity in relief forms and surface patterns often results from centuries and millennia of "self-organization".[a] Peatlands are so diverse that globally they essentially share only one characteristic: the presence of a peat layer. The lack of easy visibility of this (below-ground) peat is a reason that peatlands remain often disregarded and grouped with other habitats or are not differentiated in the various land use categories.

A common, classical distinction in peatland types is made between "bogs" and "fens". Bogs are merely fed by precipitation (i.e. they are "ombrotrophic") and consequently acid and nutrient poor. "Fens" also receive water that has been in contact with mineral subsoil (i.e. they are "minerotrophic") and are generally less acidic and more nutrient-rich. A "transitional mire" (also called "poor fen") looks like a "bog", but functions like a "fen". The term "swamp" is often used to describe forested peatlands.

The diverse interest in peatlands has given rise to dozens of different peatland typologies and hundreds, if not thousands, of different peatland types.[b] Historically, their classification often relates to how the peatlands look, where they are situated, or which resources they can deliver. Such typologies, though commonly applied, often give little information as to how the peatlands are functioning, which regulating or cultural ecosystem services they may provide, and how they may be restored after degradation. These typologies therefore often fail to address the reasons for which we currently want to conserve, restore and sustainably manage peatlands. For example, conventional definitions regarding the peat layer thickness required to describe an area as a peatland, are generally informed by agricultural considerations (e.g. plough depth), not by its climate-relevant soil carbon content, which would lead to a shallower peat depth. Given this diversity, the UNFCCC and IPCC allow countries to use a definition of peatland according to their national circumstances, provided that the concept is clearly defined and that the definition is applied consistently across the entire national land area and over time.[c]

Notes: a **Couwenberg, J., Baumann, M., Lamkowski, P. & Joosten, H.** 2022. From genes to landscapes: Pattern formation and self-regulation in raised bogs with an example from Tierra del Fuego. *Ecosphere*, 13: e4031.

b **Joosten, H., Moen, A., Couwenberg, J. & Tanneberger, F.** 2017. Mire diversity in Europe: mire and peatland types. In: Joosten, H., Tanneberger, F. & Moen, A. eds. *Mires and peatlands of Europe – Status, distribution and conservation*. Stuttgart,Schweizerbart Science Publishers.

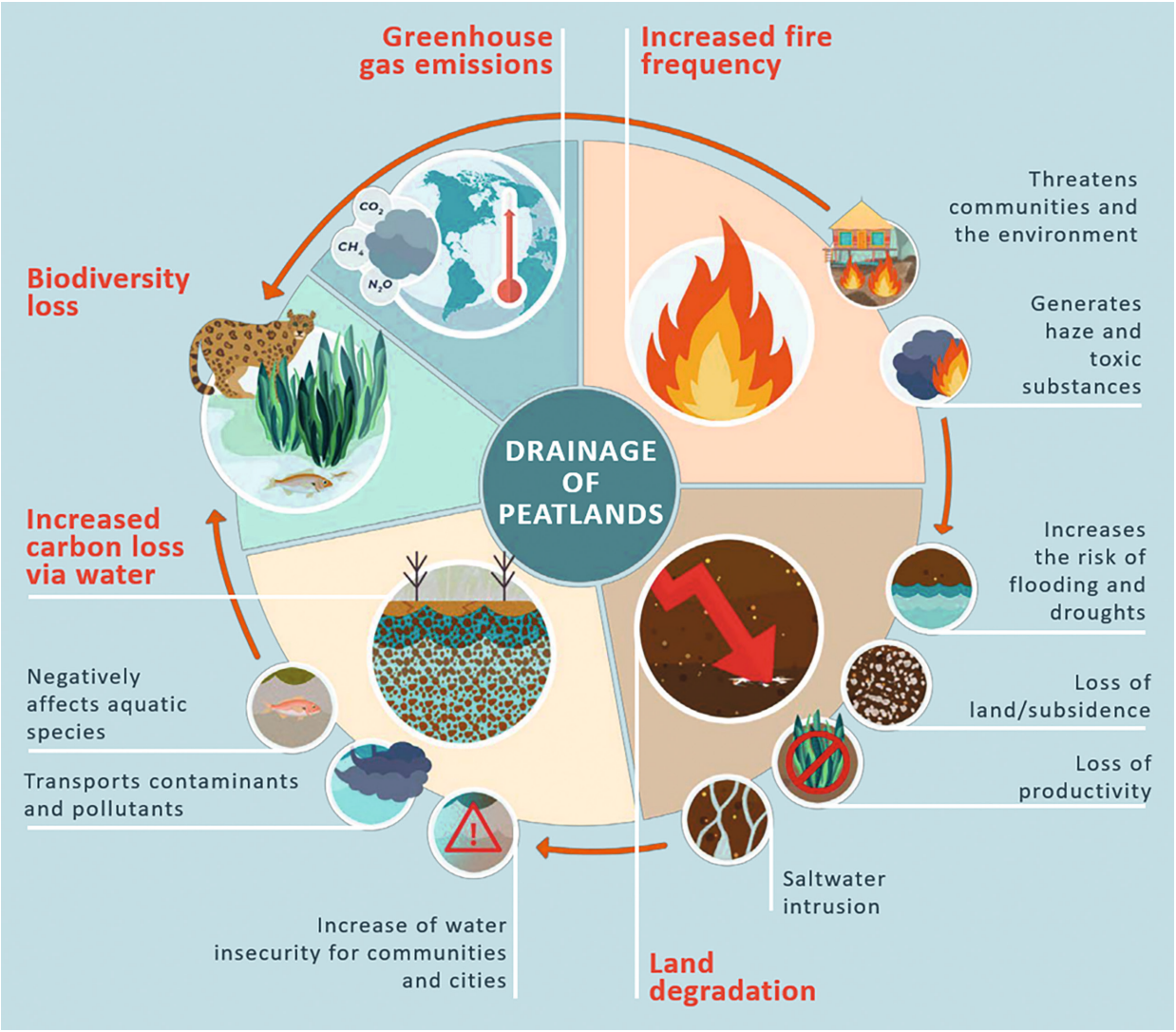
c **IPCC**. 2014. *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*. Geneva, Intergovernmental Panel on Climate Change. www.ipcc.ch/site/assets/uploads/2018/03/Wetlands_Supplement_Entire_Report.pdf

2.2 CLIMATE CHANGE ADAPTATION

Beyond GHG emissions, peatland drainage and degradation causes multiple environmental and social problems (Figure 7). The lowering of the water level leads to a direct reduction in evapotranspiration cooling in the landscape and the loss of biodiversity typical of peatlands. The mineralization and emission of nitrogen deteriorate the quality of surface and groundwater. As undrained peat is largely composed of water, drainage also causes the peatland body to subside and compact. This changes the hydraulic properties of the peat, which reduces the water storage capacity of the peat and the capacity to regulate runoff (Zeitz, 2016).

The sustainable wet management of peatlands can be described as zero-drainage peatland management, without major alterations to the hydrology nor to the peat body. Sustainable management addresses most of the challenges described and, therefore, offers an invaluable opportunity for countries to achieve their NDCs as well as the overall SDGs.

Figure 7 **Environmental and social impacts of peatland drainage**



Source: Modified after **FAO.** 2016. *Peatland and climate change*. Rome. www.fao.org/3/c0068e/c0068e.pdf

A major and much ignored consequence of peatland drainage is peatland subsidence. Drained peatlands lose peat through microbial oxidation, compaction, fire and wind erosion – depending on climate and land use – from a few millimetres (in the Boreal zone) to several centimetres of peat thickness (in the Tropics) per year (Erkens *et al.*, 2016; Evans *et al.*, 2019). The resulting subsidence of the peat surface requires a deepening of drainage ditches. This in turn promotes further subsidence and consequently further deepening of the ditches. This "vicious circle of peatland use" with continuous subsidence makes gravity-based drainage increasingly difficult and expensive, and may eventually require the installation of polder systems with dikes and pumps (Zeitz, 2016). Subsidence may be expected to increase with higher temperatures and reduced water availability as a result of climate change. In the peatland-rich Netherlands, the damage to roads and sewage infrastructure caused by peatland subsidence is estimated to be around EUR 200 million per year. By 2050, it is expected that subsidence damage to buildings will amount to EUR 80 billion (Joosten, 2022.)

As sea level rises due to global warming, peatlands are literally bogged down by drainage. Many peatlands are situated in coastal areas and only a few metres above sea level. Peatland subsidence increases the risks of flooding and the intrusion of salty seawater in these peatlands, which are often densely populated. Significant parts of the Malaysian and Indonesian peatlands, which have recently been drained for the cultivation of oil palms and pulpwood, will be flooded by the sea in the coming decades due to rapid peatland subsidence (see for example Hooijer *et al.*, 2015). It is estimated that in this century,

peatland subsidence will lead to uncontrolled flooding of 10-20 million ha of productive land worldwide. Diking, polders and pumping, i.e. the methods used in the Netherlands, North Germany, England, California or Florida, will not be implementable in the humid tropics due to the vast expanse of land and the enormous amounts of rainfall. These methods would also not stop the subsidence and would only slightly delay the inevitable abandonment of drainage-based land use (Joosten *et al.*, 2012).

In more continental and hotter climates, frequent water level fluctuations lead to the formation of cracks in the drained peat. This frustrates capillary water rise and leads to even more frequent and deeper drying of the soil. Eventually, a loose, fine-grained, hydrophobic (water-repellent) topsoil develops, which is, if at all, at best home to desert species. In Eastern Europe, millions of hectares of former peatland wetlands have in this way changed into arid deserts within a few decades (Joosten *et al.*, 2012, 2016). It is clear that peatland drainage is causing a loss of land when it is needed the most to support increased populations, to enable poverty reduction, and to replace fossil resources. There are various challenges facing drained peatlands, but only one ultimate solution: full rewetting, i.e. raising the mean annual water table level as close to the peat surface as possible in the entire peatland, e.g. peatland hydrological unit. Table 2 summarizes the problems associated with peatland drainage, its effects on different sectors and scales, and full rewetting helping to solve these problems.

It is clear that peatland drainage is causing a loss of land when it is needed the most to support increased populations, to enable poverty reduction, and to replace fossil resources.

Table 2 **Full rewetting helping to solve problems associated with peatland drainage**

Problem	Sector impacted	Scale of impact	Solution
Fire + haze	Health, welfare, economy and politics	Local, national, regional	Full rewetting OR improved management
Emissions	Climate	Global	Full rewetting
Subsidence	Land availability, infrastructure, food security	Local, national, global	Full rewetting

Source: **Joosten, H.** 2022. Moor muss nass. Wiedervernässung vorantreiben, Torfabbau verhindern. In: K., Wiegandt, eds. *Drei Grad mehr – Ein Blick in die drohende Heißzeit und wie uns die Natur helfen kann sie zu verhindern*. pp. 209-232. Munich, Germany, Oekom.

Recent studies show the major benefits of peatland rewetting and zero-drainage management for climate change mitigation, adaptation and wider SDGs, offering an invaluable opportunity for countries to achieve their NDCs. Rewetting considerably reduces GHG emissions and can also restore the carbon sequestration function of peatlands (Wilson *et al.*, 2016; Nugent *et al.*, 2018; Mrotzek *et al.*, 2020), while these can act again as a cost-effective nitrate sink through denitrification (Trepel, 2010).

Rewetted peatlands may also contribute to flood retention. On the one hand, the damage to the area itself is lower in the event of flooding (e.g. risk of crop failure). On the other hand, the peatlands can act as retention areas to store water and delay flood events, protecting areas downstream from flooding (Joosten *et al.*, 2015). Peatland rewetting can also increase groundwater reserves in the catchment area of the peatland, as the outflow of water from the landscape is delayed. Both flood retention and the increase in groundwater supplies are important for adapting to future climate change, which, in addition to a general warming, will also lead to a redistribution and greater extremes of precipitation and dry periods. Rewetting can also contribute to climate change adaptation by providing cooling, because more solar energy is used for evapotranspiration and less is available for warming the air (Joosten *et al.*, 2015; Worrall *et al.* 2022). The increase in biodiversity typical of peatlands as a result of rewetting is also worth mentioning (see for example Herold, 2012).

Box 2

Indonesia's mid-term climate contributions and peatland restoration

By 2022, Indonesia has submitted three NDC updates, the latest in September 2022. Following the UNFCCC guidance, the latest update is in force. This box contains a brief analysis of the content of the submissions and the enhancements in the ambition including both mitigation and adaptation aspects.

Indonesia submitted its first NDC in 2016 for targets by 2030 and against the 2010 business-as-usual (BaU) baseline scenario. The 2016 and the updated NDC[a] in 2021 had very similar GHG reduction targets. In 2022, Indonesia increased its mid-term GHG reduction target through the enhanced NDC (ENDC).[b] The ENDC has an unconditional target of 31.89 percent and a conditional target of 43.20 percent by 2030. The ENDC is the transition towards Indonesia's second NDC, which will be submitted in 2024 to be aligned with its Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050 or LTS).[c]

The current ENDC provides nine programs to ensure the implementation of NDC. These include a GHGs-data policy to enhance transparency at the national level and a monitoring and review of NDC by an established inter-ministerial team to monitor the progress and achievements.

The NDC categorizes actions under five sectors: 1) energy, 2) waste, 3) industrial processes and product use (IPPU), 4) agriculture, and 5) forestry and other land uses (FOLU). Peatlands are only mentioned under the FOLU sector.

Projected emission reductions in the FOLU sector as mitigation measures are estimated from reduced deforestation, avoided forest degradation, land rehabilitation, peatland restoration, and the latest inclusion of improved peatland water management – i.e. raising water levels up to 50 cm from the surface in palm oil and timber plantations to reduce peat decomposition. These FOLU sector projected emission reductions account for 55 percent of the total from the unconditional target and 59 percent of the conditional target, indicating the prominence of the sector – and peatlands in particular. The restoration of degraded peatlands and mangroves is mentioned explicitly as an action to achieve ecosystem and landscape-level resilience to support adaptation efforts.

Indonesia has implemented ambitious emission reduction action through peatland restoration, especially since 2016. The country estimated a successful peatland restoration rate of 90 percent of the 2 million ha target set by 2030. While more information would be still needed on the criteria and indicators for successful peatland restoration, the NDC clarifies the following points:

1. The BAU scenario assumes no restoration activities.
2. Peatland restoration efforts estimate the peatland emission reductions both by rewetting and revegetation.
3. Restored peatlands are assumed to have zero peat decomposition.

According to the IPCC Wetlands Supplement (2014) and the latest Ramsar guidance for peatland restoration (Convention on Wetlands, 2021 a, b and c), to minimize emissions, restoration would require full rewetting up to the surface of the entire peatland hydrological unit, with all canals blocked.

Notes: a **Republic of Indonesia.** 2021. *Updated Nationally Determined Contribution.* www4.unfccc.int/sites/ndcstaging/publisheddocuments/indonesia%20first/updated%20ndc%20indonesia%202021%20-%20corrected%20version.pdf

b **Republic of Indonesia.** 2022. *Enhanced Nationally Determined Contribution.* https://unfccc.int/sites/default/files/NDC/2022-09/ENDC%20Indonesia.pdf

c **Republic of Indonesia.** 2021. *Indonesia Long-Term Strategy for Low Carbon and Climate Resilience 2050 (Indonesia LTS-LCCR 2050).* https://unfccc.int/sites/default/files/resource/Indonesia_LTS-LCCR_2021.pdf

2.3 DRIVERS OF CHANGE

Analysing the drivers of peatland drainage and degradation in a specific landscape (Figure 8) is key to protection, restoration and sustainable management efforts. Unlike forests on mineral soil, all parts of a peatland are interconnected by its hydrology. Damage to one small area can therefore impact the entire peatland. Cross-sectoral and multi-level (national, provincial and local) approaches are required to address the drivers of change.

Historically, there was little knowledge of the multiple ecosystem services provided by peatlands and the deleterious effects of peatland drainage. Peatlands were generally seen as non-productive areas that needed to be drained in order to make a profit out of the land. This translated into large revenues, but has also led to numerous issues (as highlighted in this chapter) with costs that are likely to largely outweigh the benefits.

Figure 8 **Examples of major drivers of peatland drainage and degradation**

Photos: (1) Oil sands mining; (2) draining for cattle pasture; (3) peat extraction for horticultural growing media; (4) peat extraction by sod cutting for fuel; (5) peat extraction site with a rice plantation in a cut-over peatland; (6) palm oil fruit; and (7) a wildfire.

Drainage and conversion

In Europe, drainage and conversion of peatland to agriculture has facilitated the efficient production of food crops and dairy products for many centuries and continues to this day. In the tropics, peatland utilization started mainly after 1900 for agriculture (e.g. palm oil), tree plantations and other forestry activities, and human settlement by forest removal, fires and drainage.

Extensive commercial forestry plantations have been established on peatlands in many nations. In several countries, peat is still extracted and burned for energy. Most peat is currently being used as the most preferred and valuable raw material for growing media for industrial horticultural plant production. Peat has many other uses, including for insulation, flavouring alcoholic drinks (whiskey), water purification, therapy, medicine and textiles. All these uses support small and large businesses that generate billions of dollars annually and provide livelihoods to many thousands of people (Joosten and Clarke, 2002).

Significant damage to peatlands is also caused by infrastructure projects, such as the development of roads, oil and gas exploration and production. Pipelines to major urban areas often run through forests and peatlands. Important sources of liquid energy are found in peatlands, such as in Prudhoe Bay (Alaska, the United States of America), the Pastaza-Marañón Foreland Basin (Peru), the Niger Delta (Nigeria), Siberia and Kamchatka (the Russian Federation) (Joosten, 2022). The huge peat swamp forests in the Congo Basin, which have only just been described and hardly explored, are currently being auctioned as concessions for oil and gas (Dargie *et al.*, 2018). Oil exploration in the oil sands of Alberta (Canada), is currently destroying peatland on a large scale (Rooney *et al.*, 2012). In the Hudson Bay Lowlands, Ontario (Canada), the second largest peatland area on earth, there are currently 13 296 mining claims for diamonds, chrome, nickel, copper, gold and platinum, covering over 2 000 km^2 within Ontario's "Ring of Fire" (Harris *et al.*, 2022). For peatlands in Mongolia and mountainous areas such as the Andes, mining is also a major threat, together with overgrazing (Asian Development Bank, 2017; Maldonado Fonkén, 2014). Rwanda opened its first peat-fired power plant in 2017 in Gishoma near the border with the Democratic Republic of the Congo. Another and a much larger power plant is due to open soon in Gisagara, in the east of the country using peat extracted from the large valley peatland on the Rwanda-Burundi border (Cole, 2017; Mugerwa *et al.*, 2019).

An estimated 85 percent of the world's peatlands remain largely unused and undrained. Threats and actual damage are, however, on the rise. One driver is the rapid expansion of agriculture and forestry, often accompanied by deforestation, in the tropics. Plantations of oil palms, pulpwood, aloe, pineapple and bananas are encroaching on peat swamp forests, as well as small-scale smallholder areas, which are also relevant in the aggregate at the landscape scale. Until recently, only the peatlands in Southeast Asia were subject to rapidly expanding drainage-based peatland use, in recent years followed by New Guinea Island, Western Amazonia and West Africa. A similar expansion is occurring in East and Southern Africa, where increasing population pressure is pushing people into the last, previously unused areas: peatlands (Joosten, 2022).

To stop these threatening developments is anything but simple. Arlette Soudan-Nonault, Minister for the Environment in the Republic of the Congo, concisely described it in 2021: peatlands are an important ecosystem not only for the two Congos, "but also for the entire planet". The Republic of the Congo, she said, is committed to protecting peatlands. However, "we are not naïve and we do not intend to stop our development, just so the planet can breathe easier. The invaluable ecosystem service that our peatlands and forests render to the planet cannot remain free forever, to the detriment of our population's aspiration for well-being." (Mongabay, 2021).

The situation is as clear as it is precarious. Developing countries cannot be expected to provide ecosystem services for the world without being adequately compensated for it. Conversely, short-term profits can quickly turn into major disadvantages and long-term environmental and social costs both locally and globally. The countries of the global North have limited or no credibility to communicate this as they have cleared a large part of their own forests and drained their peatlands. It is therefore vitally important that a South-South connection has been established, in which the tropical peatland giants can exchange ideas and advise each other, as with the UN Global Peatlands Initiative, the Brazzaville Declaration and the Peatlands Resolution of the United Nations Environmental Assembly. For example, Indonesia has sent many of its specialists to Africa and invited representatives of the Democratic Republic of the Congo, Republic of the Congo and Peru to Indonesia to share their lessons learned. The upcoming Global Peatlands Assessment by UNEP (2022) and partners contains the most updated list of drivers of change for peatlands in each region of the world.

Fires

Fires, which are practically non-existent inside wet peatlands may occur in drained and degraded peatlands. Siberian and Southeast Asian peatland fires are the most known ones. Another feature to take into account in disaster risk management is that sites that have already burned in the past may be more susceptible for the recurrence of fires. This way, fires invited by drained peatlands may stimulate further fires and the related cocktail of greenhouse gas emissions. Peat fires furthermore destroy the seed bank of the soil, reducing the likelihood of spontaneous wetland vegetation returning after rewetting.

In tropical countries such as Indonesia, the use of fires to clear drained peatlands for agriculture is a common practice as it is the cheapest and fastest method (Kiely *et al.*, 2021; Simorangkir, 2006). The risk of detrimental fires significantly increases in drier years mostly associated with the El-Niño phenomena (Kieft *et al.*, 2016). Notably, the El-Niño years of 1997, 2006, and 2015 were characterized by extreme droughts, which fueled small fires that started within agricultural lands and escaped into the nearby peat areas turning into persistent and prolonged fires (Pan *et al.*, 2018).

© Greifswald Mire Centre/H. Joosten

Chapter 3

Enhancing climate action

© Greifswald Mire Centre/H. Joosten

Chapter 3

Enhancing climate action

To achieve the goals of the Paris Agreement, profound economic and social transformation is required. As already highlighted in Chapter 2, peatlands are an instrumental element to achieve these goals, providing opportunities for climate change adaptation and mitigation. This chapter explores the main features of the climate commitments and the UNFCCC framework and describes their linkages with peatlands. It also shares a preliminary results of an analysis on how wetlands and organic soils were included in the climate commitments by 23 September 2022. Key aspects that help create conditions for different stakeholders involved in peatland management to engage in climate action are also detailed.

This chapter discusses how peatlands can be integrated in domestic climate commitments and measures. It highlights how improved peatland management and transparent monitoring efforts can help countries with carbon-rich peatlands leverage these unique ecosystems in climate action. The role of long-term planning with secured financial streams to support nationally-relevant low-carbon development initiatives and to enable adaptation to the effects of climate change are also explored. The Chapter gives examples and links to relevant tools and resources.

3.1 THE COMMITMENT PROCESS

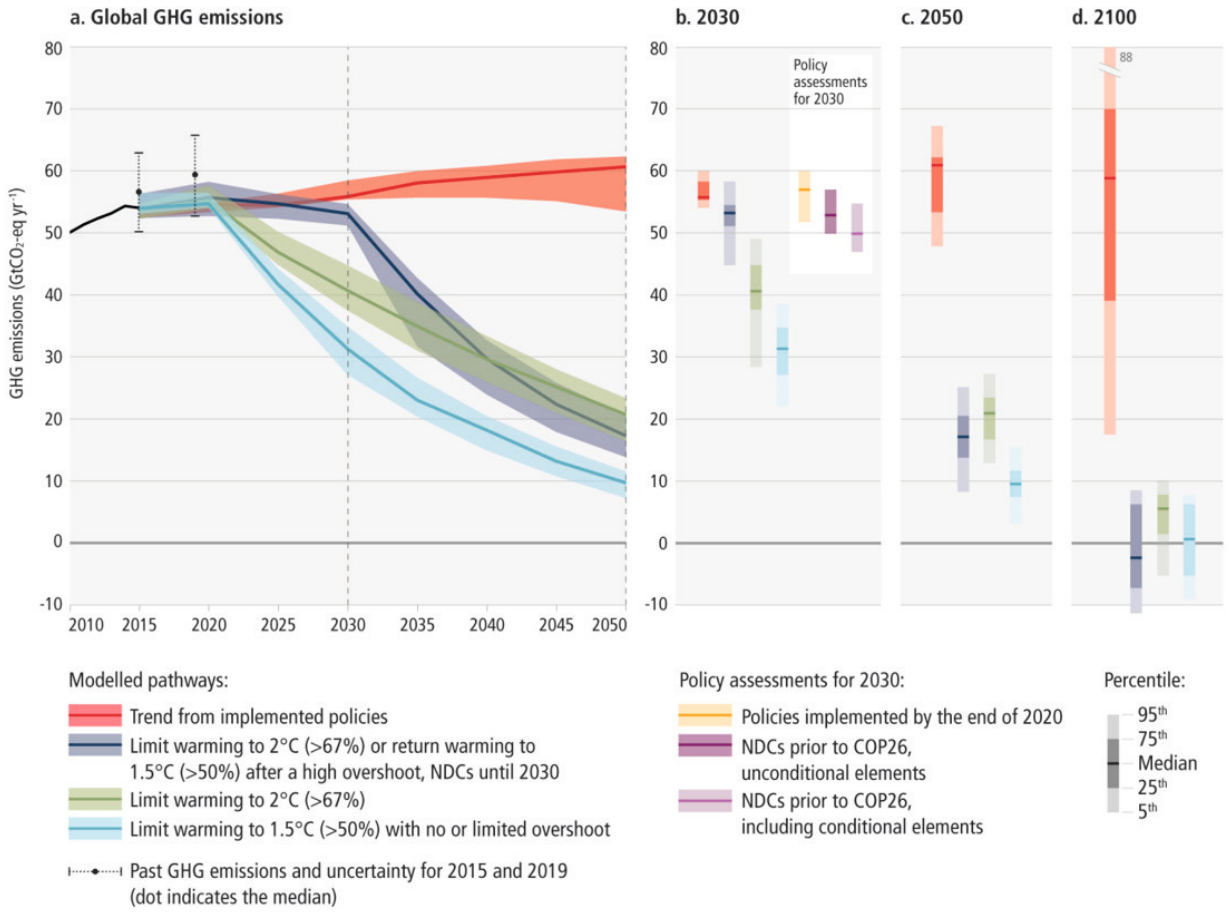
NDCs are action plans that formulate how a country aims to reduce its GHG emissions and adapt to climate change. Their formulation is led by the ministry – or ministries – in charge of implementing the Paris Agreement. In most cases, NDCs go through a consultation process with relevant stakeholders, such as the private sector, other public entities, civil society, academia, and local communities. NDCs are recorded in a public registry maintained by the UNFCCC secretariat (in accordance with Article 4, paragraph 12 of the Paris Agreement).

At least every five years, countries are required to submit their updated NDCs to the UNFCCC secretariat (i.e. by 2025, 2030). Each NDC should reflect higher ambition than the previous one. The Glasgow Climate Pact (2021) encouraged Parties to reconsider and strengthen their 2030 targets and submit updated and enhanced NDCs by the end of 2022. The Pact highlighted the urgent need for NDCs to align with the goals of the Paris Agreement, taking into account countries' respective national circumstances, including the COVID-19 pandemic (UNFCCC, 2021a).

The Glasgow Climate Pact in 2021 encouraged Parties to reconsider and strengthen their 2030 targets and submit updated and enhanced NDCs by the end of 2022.

As of September 2022, all of the 194 Parties to the Paris Agreement have submitted their first NDCs, and some have even submitted a 3rd or a 4th version. A total of 151 Parties have communicated updated NDCs targets. According to the Climate Action Tracker, however, these targets still fall short and would limit warming to, at most, 2.4oC (CAT 2022). More ambitious targets are therefore required. Figure 9 shows global emissions under different pathways assessed in the IPCC 2022 Report on Mitigation of Climate Change, with total global emissions according to NDCs submitted by 11 October 2021.

Figure 9 Global GHG emissions of modelled pathways



Legend: Global GHG emissions of modelled pathways (funnels in Panel a. and associated bars in Panels b., c., and d.) and projected emission outcomes from near-term policy assessments for 2030 (panel b).

Source: **IPCC.** 2022. Figure SPM.4 from: Summary for Policymakers. In: P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, eds. *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, UK and New York, USA, Cambridge University Press. DOI: 10.1017/9781009157926.001

The need for increased ambition in climate commitments responds to the fact that in 2010-2019 average annual global GHG emissions were at their highest levels in human history (IPCC, 2022). Unless climate change is addressed quickly, global warming is unlikely to be limited to 1.5°C above pre-industrial levels. To achieve the goal of achieving 1.5 °C, GHG emissions must peak before 2025 at the latest, and be reduced by 43 percent by 2030, with the aim to reach net zero in the early 2050s (IPCC, 2022). Emission reductions should be undertaken on the basis of equity, supporting the efforts to reach the SDGs, including poverty eradication. Net zero means cutting GHG emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by, for example, peatlands, oceans and forests. As there is high uncertainty on the potential of ecosystems to absorb carbon from the atmosphere under the current and future effects of climate change, it is vitally important that GHG emissions are reduced to as close to zero as possible.

The global stocktake of the Paris Agreement will assess the progress on implementation of national climate commitments (NDCs) and towards achieving the long-term goals of the Agreement. It will have

three thematic areas on 1) mitigation, 2) adaptation and 3) means of implementation and support. The collection of information and technical assessment has already started, and the outcome of the first global stocktake in 2023 shall inform countries in further updating and enhancing their NDCs.

As there is high uncertainty on the potential of ecosystems to absorb carbon from the atmosphere under the current and future effects of climate change, it is vitally important that GHG emissions are reduced to as close to zero as possible. [...] The focus with respect to peatlands should be on avoiding and reducing emissions.

Peatlands are a major carbon sink compared to terrestrial forests and oceans. Tropical peatlands have higher sequestration rates over the past 10 to 125 years compared to boreal and temperate peatlands. These rates are higher than those of terrestrial forests and oceans with sequestration rates below 50 g C m^{-2} $year^{-1}$ (Temmink *et al.* 2022).

As the rate of carbon losses from drained peatlands is an order of magnitude higher than the rate of carbon sequestration in wet peatlands, the focus with respect to peatlands should be on avoiding and reducing emissions. The inclusion of peatland conservation, restoration and sustainable management in the NDCs represents a significant opportunity to mitigate and avoid carbon emissions (see 2.1 Fragility, uniqueness and emission reductions).

Box 3

The Democratic Republic of the Congo and its commitments

The Democratic Republic of the Congo enhanced NDC focuses on long-term adaptation by securing communities' livelihoods, forest resource management and protecting vulnerable ecosystems, such as peatlands.[a] The first NDC (2017), established a conditional emissions reduction target of 17 percent by 2030 compared to a BAU scenario. Priority sectors for mitigation were agriculture, forests and energy, and for adaptation, the target was livelihoods and the rational use of resources and coastal areas.[b] However, peatlands were not specifically addressed in the first submission.

The Democratic Republic of the Congo's second NDC submission in 2021 established a GHG reduction goal of 21 percent by 2030 for all sectors. The mitigation measures mainly concern the forestry sector and are linked with the national REDD+ strategy. The country has engaged to improve the data collection and management system, seeking to formalise institutional arrangements that support data collection and reporting on a long-term basis. Extensive peatland areas recently described in the Congo Basin were estimated at 167 600 km^2 with a carbon stock of 29 000 Mt.[c,d] The Democratic Republic of the Congo holds two-thirds of this peatland area.

Wetland restoration measures are included e.g. restoration of peatlands used for agriculture and grazing. To avoid future emissions by peatland degradation, integration of forests and peatlands in land-use plans is proposed. Transparency and consultation are expected to take place before land-use concessions for agriculture, forestry, mines and hydro-carbon are awarded. An agreement between the Democratic Republic of the Congo and the Central African Forest Initiative (CAFI) for the period 2022–2031 was launched at the UNFCCC COP26 in 2021. In this, the country does not intend to award industrial agricultural concessions in peatlands and calls to reduce the impact of mining and oil investments on forests and biodiversity, with reinforced measures in high value forests and peatlands.[e] It will also orient agricultural development towards the savannahs.

Seven priority actions are defined for peatlands, without defined targets for mitigation nor adaptation:

Establish guidelines and protocols for the legal protection of overlapping land uses in peatlands.

1. Establish clear protections for peatlands in the 2002 Forest Code, by building on the Sustainable Forest Management Programme (PGDF) and the Democratic Republic of the Congo's REDD+ investment plan for 2021–2030 in consideration of the high value of peatlands in terms of carbon storage and sequestration.
2. Ensure that the National Peatland Strategy incorporates conventions and initiatives commitments achieving international support for protecting and managing peatlands, including the Ramsar Convention.
3. Strengthen national peatland capacity and expertise, on both an institutional and technical level.
4. Use the current interest in Congo Basin peatlands to enhance and protect them.
5. Prepare a plan for communication, information, and education related to the national peatland capacity development programme.
6. Link the National Peatland Strategy to international, sub-regional, and national initiatives related to the management and enhancement of peatlands.

Notes: a **Democratic Republic of the Congo**. 2021. *Contribution Déterminée à l'échelle Nationale révisée*. https://unfccc.int/sites/default/files/NDC/2022-06/CDN%20Revis%C3%A9e%20de%20la%20RDC.pdf

b **Sonwa, D.J., Lewis, S.L., Ifo, S.A., Ewango, C., Mitchard, E.T.A., Dargie, G.C., Lawson, I.T., *et al.*** 2022. Les tourbières de la cuvette centrale du bassin du Congo: Réalités et perspectives. In: R., Eba'a Atyi, F., Hiol Hiol, G., Lescuyer, P., Mayaux, P., Defourny, N., Bayol, F., Saracco, D., Pokem, R., Sufo Kankeu, R., Nasi, eds. *Les forêts du bassin du Congo: état des Forêts 2021*, pp. 255–282. Bogor, Indonesia, CIFOR. https://doi.org/10.17528/cifor/008565

c **Dargie, G.C., Lewis, S.L., Lawson, I.T., Mitchard, E.T.A., Page, S.E., Bocko, Y.E. & Ifo. S.A.** 2017. Age, extent and carbon storage of the Central Congo Basin peatland complex. *Nature*, 542: 86–90.

d **Crezee, B., Dargie, G.C., Ewango, C.E.N., Mitchard, E.T.A., Emba B.O., Kanyama T., J., Bola, P., Ndjango, J.B. N., Girkin, N.T., Bocko, Y.E., Ifo, S.A., Hubau, W., Seidensticker, D., Batumike, R., Imani, G., Cuní-Sanchez, A., Kiahtipes, C. A., Lebamba, J., Wotzka, H.-P., Bean, H., Baker, T. R., Baird, A. J., Boom, A., Morris, P. J., Page, S. E., Lawson, I. T. & Lewis, S. L.** 2022. Mapping peat thickness and carbon stocks of the central Congo Basin using field data. *Nature Geoscience*. https://doi.org/10.1038/s41561-022-00966-7

e **CAFI**. 2021. *Decision of the CAFI executive board meeting: Democratic Republic of the Congo Letter of Intent and Country Allocation*. EB.2021.18 www.cafi.org/sites/default/files/2021-11/EB.2021.18%20-%20Letter%20of%20Intent%20with%20the%20DRC%202021-2030%20with%20annexes.pdf

Long-term engagement

While NDCs are intended for the medium-term (5-10 years), ambitious long-term strategies are needed to enable profound societal changes that avoid the predicted devastating effects if the earth warms beyond 2°C (IPCC, 2018). Under the UNFCCC countries are invited to communicate "mid-century, long-term low greenhouse gas emissions development strategies, or LTS". Unlike NDCs, LTS are an opportunity for countries to articulate their plans for achieving zero-emissions by 2050. To steer societal changes and provide a stable and predictable environment, countries would benefit from aligning their NDCs and LTSs. This will also ensure coherence and help avoid carbon-intensive economic development. By 24 October 2022, 53 Parties have submitted LTSs (UNFCCC, 2022a).

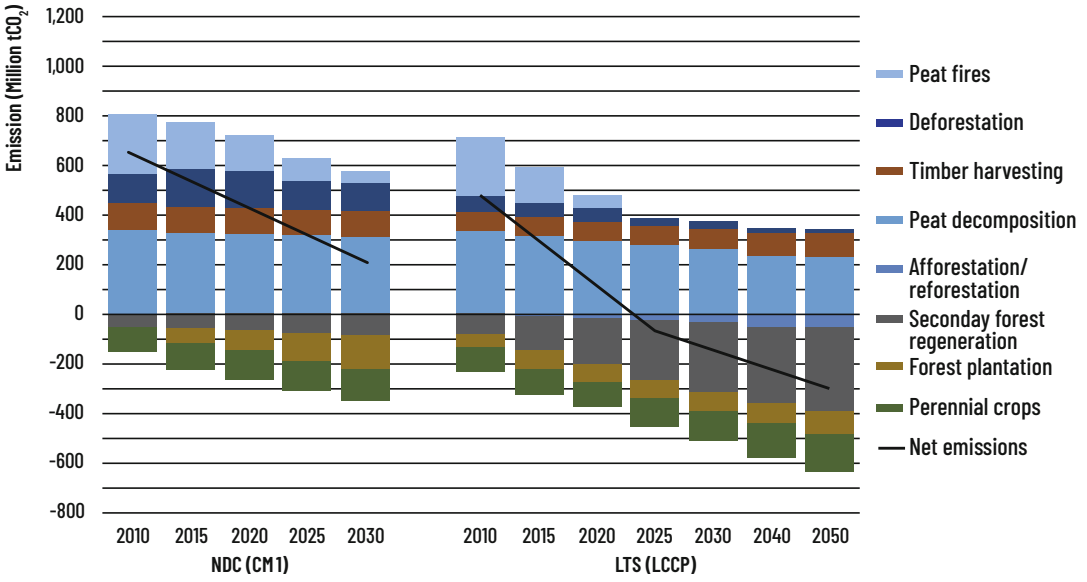
© U.S. Forest Service International Programs/Eva McNamara

Box 4

Indonesia's Long-Term Strategy

In 2019, two years before officially submitting its first LTS to the UNFCCC, Indonesia developed a national long-term climate strategy: called Low Carbon Development : A paradigm Shift towards a Green Economy in Indonesia.[a] In 2021, it submitted a long-term climate vision called Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050 or LTS).[b] Both instruments explore scenarios in the same sectors based on the same impact, potential reduction in GHG emissions and economic growth. The LTS also highlights GHG reduction in 2030, linking with Indonesia's NDC target. It laid out strategies to further reduce carbon and energy intensity with the aim to reduce GHG emissions by 43 percent by 2030. The LTS communicates Indonesia's target of peaking the national GHG emissions by 2030 through a FOLU net sink, reaching 540 $MtCO_2eq.$ by 2050 (10 $MtCO_2eq.$ more than the level estimated in 2000). The LTS also sets the target to progress towards net-zero emissions by 2060, or sooner.

Figure 10 **Forest and land use sector emission projections in Indonesia**



Source: **Ministry of Environment and Forestry of Indonesia**. 2022. *Operational Plan: Indonesia's FOLU Net Sink 2030*. www.menlhk.go.id/site/single_post/4705/operational-plan-indonesia-s-folu-net-sink-2030

In the Operational Plan of Indonesia's FOLU Net Sink 2030,[c] the FOLU sector plays a key role to offset emissions from sectors that are difficult to abate, such as the energy sector. Figure 10 shows the FOLU sector emission projections in unconditional Nationally Determined Contribution (NDC, on the left) and Long-Term Strategy for Low Carbon and Climate Resilience scenarios (LTS, on the right) in Indonesia. The efforts to reduce emissions from the FOLU sector and to become a net sink by 2030 largely depend on the success to reduce emissions from fires and peat decomposition by improved peatland management.[d]

LTS-LCCR 2050 sets the adaptation strategy to reduce national GDP loss due to climate change by 3.45 percent in 2050. The strategy focuses on the resilience of the four basic necessities: food, water, energy and environmental health. The LTS also builds on the same resilience pathway mentioned in the NDC.

In the LTS, Indonesia elaborates three scenarios mitigating the risk of climate change: i) the current policy scenario; ii) the transition scenario; and, iii) the low-carbon scenario compatible with the Paris Agreement. These scenarios include implications on per capita income and required investment costs from the government. The prominence of FOLU sector's potential to reduce national GHG emissions shows how the scenarios are first modelled by separating AFOLU (including agriculture and FOLU sectors) and the non-AFOLU sectors. Economic and population growth are determined as the key drivers for changes in food and energy demand for both models. Economic and economic impacts were then analysed for both AFOLU and non-AFOLU sectors. There are

no assumptions presented that differentiate the GHG estimation of the three scenarios.

The current policy scenario and low-carbon scenarios call for significant emission reduction from AFOLU. These scenarios suggest a further decrease in emissions from deforestation and peatlands (peat fire and peat decomposition). They also require increased carbon sequestration in secondary forests through afforestation and reforestation. FOLU net sink is expected by 2050 under current policy and by 2030 under low-carbon scenarios. This target therefore mandates peatland restoration and avoiding deforestation on peatlands to meet these expectations. Ministerial Regulation of the Minister for Environment and Forestry No. 15/2017 mandates the private sector, such as plantation owners, and local governments to improve the use of peatland and water management by measuring and regulating groundwater levels. The Ministry of Environment and Forestry estimates different areas covered by (1) improved peatland and water management and (2) peatland restoration, under current policy scenario and low-carbon scenario by 2030 and by 2050 (in million hectares), as shown in Table 3.

Notes: a **Ministry of National Development Planning of Indonesia.** 2019. *Low Carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia*. Cited 10 November 2022. https://drive.bappenas.go.id/owncloud/index.php/s/ZgL7fHeVguMi8rG#pdfviewer

b **Republic of Indonesia.** 2021. *Indonesia Long-Term Strategy for Low Carbon and Climate Resilience 2050 (Indonesia LTS-LCCR 2050)*. https://unfccc.int/sites/default/files/resource/Indonesia_LTS-LCCR_2021.pdf

c **Ministry of Environment and Forestry of Indonesia**. 2022. *Operational Plan: Indonesia's FOLU Net Sink 2030*. www.menlhk.go.id/site/single_post/4705/operational-plan-indonesia-s-folu-net-sink-2030

Table 3 **Areas covered by improved peatland and water management and peatland restoration in Indonesia**

Management practices	Current policy scenario		Low-carbon scenario	
	By 2030	By 2050	By 2030	By 2050
Improved peatland and water management	0.86 Mha	1.04 Mha	0.95 Mha	1.04 Mha
Peatland restoration	1.03 Mha	1.7 Mha	2.7 Mha	4.2 Mha

Source: **Republic of Indonesia.** 2021. *Indonesia Long-Term Strategy for Low Carbon and Climate Resilience 2050* (Indonesia LTS-LCCR 2050). https://unfccc.int/sites/default/files/resource/Indonesia_LTS-LCCR_2021.pdf

Welfare improvements are estimated to occur under all scenarios, with significant improvements to personal income as well as state expenditure under all scenarios. The low-carbon scenario is not expected to have a major economic impact in the Indonesian economy.

3.2 CURRENT INCLUSION OF PEATLANDS IN CLIMATE COMMITMENTS

A review of NDCs submitted between 2015 and 23 September 2022 conducted by FAO in collaboration with Greifswald Mire Centre shows that only 22 countries of the 147 parties (i.e. including the European Union that consists of 27 countries) specifically mention peatlands in one or several of their NDC submissions. Some of the parties specify concrete targets and/or measures. These parties are known to have peatlands in their territories. Table 4 to Table 7 provide examples of measures on peatlands included in the studied NDCs.

Many countries may refrain from mentioning peatlands due to a lack of awareness of their importance. Other countries hesitate to address peatlands due to a lack of knowledge as to whether the countries' territories contain peatlands, where they are, in what condition they are in, and how much they can contribute to achieving (or undermining) the Paris Agreement and wider sustainability goals. Inclusion of peatlands and organic soils in NDCs may be further hindered by budgetary, institutional (unclear sectoral responsibility), capacity (lack of expertise and tools) or legal constraints. However, these constraints constitute a major reason to include peatlands in NDCs: to request technical and financial support for peatland inventory and capacity development to be able to implement climate action. See Figure 11 and Figure 12.

Table 4 Sub-Saharan Africa: Examples of peatland measures

Country	Examples of measures in NDC
Cameroon	Restore organic soils and promote research on natural resource management.
Republic of the Congo	Recognition of the environmental strategy on sustainable management and conservation of peatlands. Not mentioned as mitigation action.
Côte d'Ivoire	Sustainable management of organic soils to improve agricultural production capacity and enhance environmental resources.
The Democratic Republic of the Congo	Restore wetlands, including peatlands used for agriculture and livestock (estimated cost of USD 1.3 billion). Mapping and evaluating peatlands (estimated cost USD 0.52 billion). A Peatland National Strategy exists.
Eswatini	Restoring and protecting wetlands (areas of marshes, fens, peatlands or water, including artificial, permanent or temporary) for adaptation.
Gabon	Mitigation contributions include the carbon in drained organic soils for savannah and cropland.
Namibia	Blue economy as part of adaptation activities includes coastal agriculture and the use of irrigation water-saving technologies and organic soil nutrient sources.
Rwanda	Mitigation in the energy sector includes displacement of GHG emissions from fossil fuel power generation (peat, diesel oil).
Uganda	Peatland restoration is a priority adaptation action for enhanced ecosystems resilience and as a mitigation action in the agriculture, forestry and other land use (AFOLU) sector.

Table 5 **Asia and the Pacific: Examples of peatland measures**

Country	Examples of measures in NDC
Afghanistan	Mitigation measures for N_2O include less use of histosols.
Brunei Darussalam	Peatlands mentioned as part of the forest cover. Measures included to address the impact of deforestation in peat swamp forests, and the subsequent impacts to the country's economy.
Indonesia	Reductions of GHG emissions in the forestry sector, where peat fire emissions dominate, by restoration of 2 million ha of peatlands by 2030.
Malaysia	Enhancing adaptation for forestry and biodiversity: expanding protected areas, including fisheries zones within the marine and coastal protection corridors as a priority. Increasing management units in the riparian area and reserving larger buffer areas around wetlands, peat swamps and mangroves. LULUCF pools include soil organic carbon and drained peatlands.
Mongolia	Enhancing adaptation and resilience through protection and sustainable management of vulnerable and unique ecosystems. Includes a pilot research project on climate change in different landscapes covering high mountains, forest, meadows, fresh water, wetlands, peatlands, steppe, Gobi Desert, and others.
Myanmar	As part of the agricultural sector, future efforts may be made to quantify below-ground biomass, and soil organic carbon, with particular priority for agroforestry in mangroves and peatland soils.
Pakistan	Conservation and restoration of mangroves, peatland ecosystems, and coastal and marine ecosystems to reduce emissions and revive natural carbon sinks. Increase in restored area as carbon sink. A National Wetland Policy exists.

Figure 11 shows the regional distribution of contributions mentioning peatlands according to the two submission periods, or "cycles": the first one from 2015 to 2019, and the second from 2020 and until 23 September 2022 – i.e. the cut-off date for the analysis. A special case is for the EU, which has a joint NDC for all the member countries. To date, the EU has not mentioned peatlands explicitly in its NDC. A bigger share of contributions has included wetlands, mangroves, and other types of wetlands between the two cycles, see Figure 12. For this Figure, the percentage of contributions (i.e. NDCs) is shown in relation to the number of NDCs analysed for countries that are known to have these types of wetlands in their territories. Yet while the trend has increased for all types of wetlands, peatlands remain largely underrepresented, see Figure 10 and Figure 12.

Table 6 **Europe and Central Asia: Examples of peatland measures**

Country	Examples of measures in NDC
Belarus	Increases the area of restored peatlands and reduces the area of degraded, reclaimed land within peat soils.
United Kingdom	Beyond communication of an NDC, the United Kingdom continues to make progress on priority policy areas that are crucial to the United Kingdom's overall approach, including the England Peat Action Plan.

Many countries may refrain from mentioning peatlands due to a lack of awareness of their importance. Other countries hesitate to address peatlands due to a lack of knowledge as to whether the countries' territories contain peatlands, where they are, in what condition they are in, and how much they can contribute to achieving (or undermining) the Paris Agreement and wider sustainability goals. Inclusion of peatlands and organic soils in NDCs may be further hindered by budgetary, institutional (unclear sectoral responsibility), capacity (lack of expertise and tools) or legal constraints. However, these constraints constitute a major reason to include peatlands in NDCs: to request technical and financial support for peatland inventory and capacity development to be able to implement climate action.

Table 7 **Latin America, the Caribbean and Northern America: Examples of peatland measures**

Country	Examples of measures in NDC
Canada	Investing $ 631 million (Canadian dollars) to restore and enhance wetlands, peatlands, grasslands and agricultural lands, as well as to improve land management practices, and conserve carbon-rich ecosystems.
Chile	By 2025, peatland areas and any other types of wetlands will be identified under a national inventory. By 2030, develop standardized metrics to evaluate the capacity of wetlands (especially peatlands) for climate change adaptation or mitigation, and actions to enhance co-benefits in five pilot sites.
Costa Rica	By 2030, actions, including conservation by indigenous peoples, to mitigate emissions from ecosystems such as forests and peatlands. By 2030, improve Payment for Ecosystem Services programme by including soils, peat bogs and others as a priority ecosystem with high potential for sequestration of carbon, identifying and increasing the sources of financing.
Panama	A National Wetland Policy exists.
Uruguay	Protection of 100% of the peatlands' area (and 50% unconditionally) based on 2016 measurements (i.e. 8.366 ha) as a mitigation measure.

Figure 11 **Regional distribution of NDCs that have mentioned peatlands (submitted between 2015 and 23 September 2022)**

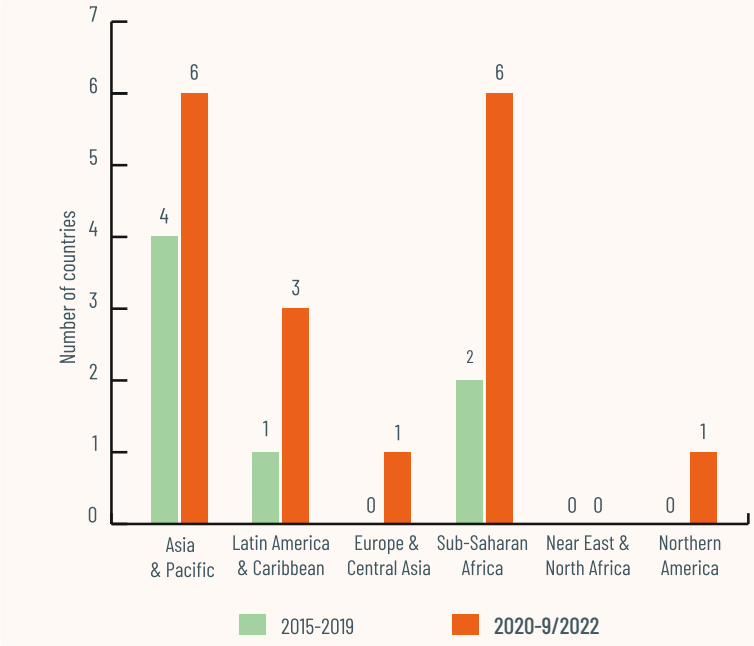
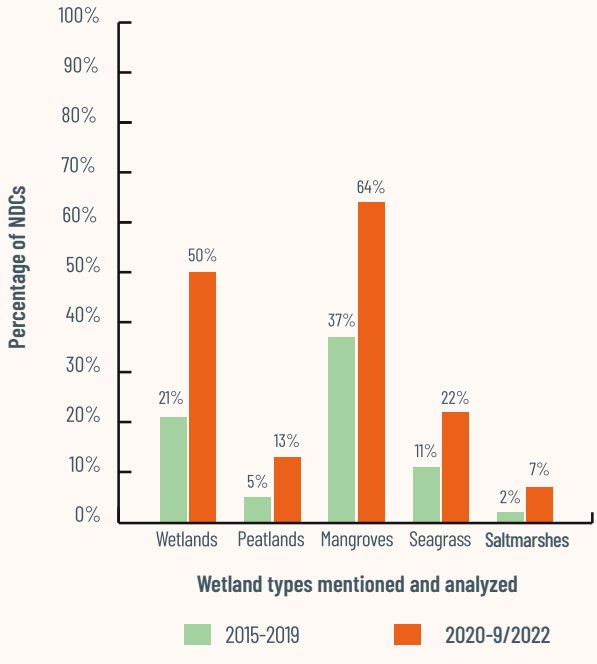


Figure 12 **Percentage of NDCs that have mentioned different types of wetlands (submitted between 2015 and 23 September 2022)**



3.3 GOOD PRACTICES

To ensure effective transition from the NDC compilation process to its implementation, monitoring and reporting, broad participation from key stakeholders as well as reliable information are essential. Transparency and accountability are necessary for clarity and mutual understanding among all stakeholders during the planning phase. They also facilitate critical actions and timely political commitments.

For NDCs to be accepted by all parts of society, public and private sectors as well as civil society and academia, Indigenous Peoples and local communities, youth, women and marginalized groups must be engaged effectively, equitably and inclusively. Benefits and opportunities of peatland-related mitigation or adaptation measures should be well understood by all stakeholders (see 3.5. KEY PEATLAND OPPORTUNITIES). In the case of peatlands, stakeholder groups may be extensive due to the diverse activities and interests linked with them. Key stakeholders that should be included are:

- water users in the area affecting peatlands' hydrology;
- hunters, fishers and other land users who may not own land, but utilize the peatland; and
- stakeholders who may have interest to extract or utilize the peat body, or the peatland vegetation.

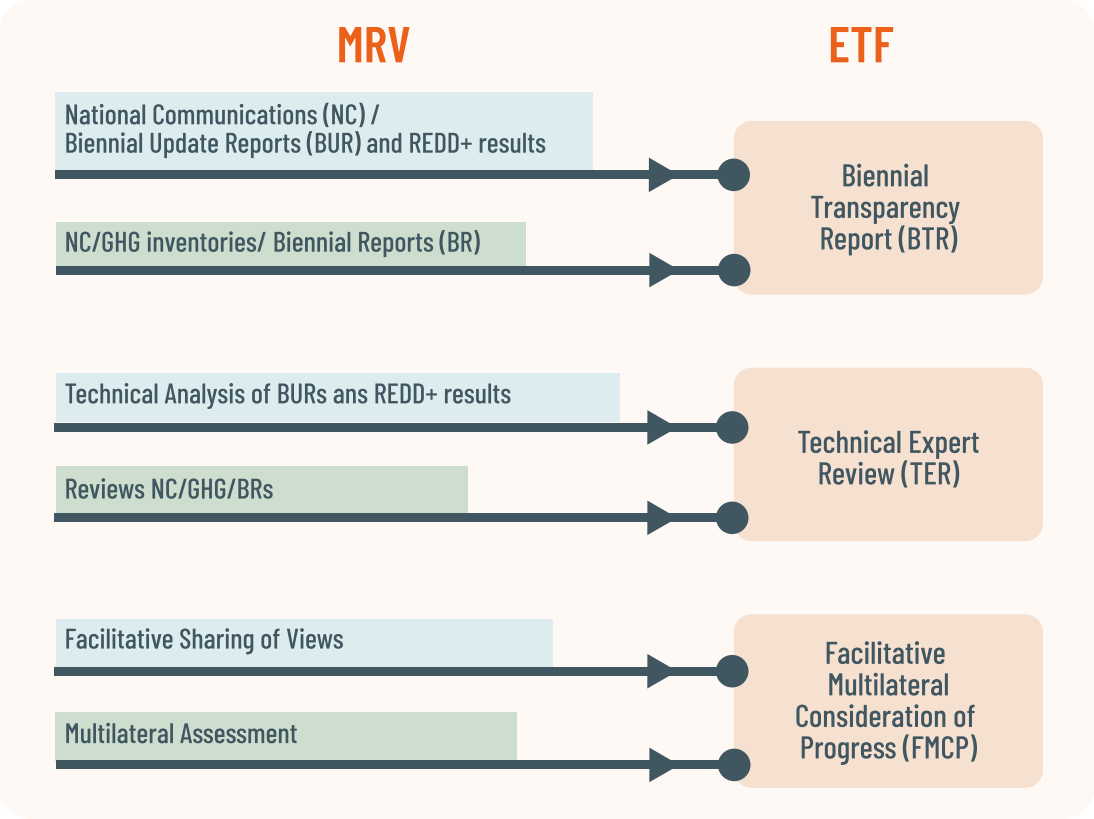
During the NDC planning phase, it is useful to define the most suitable processes, institutional structures and arrangements, and enable the conditions for effective long-term responses, e.g. sector-specific frameworks, to formulate NDC priorities. There are sector-specific frameworks to formulate NDC priorities, which provide a comparative benchmark for highlighting gaps and entry points for raising ambition, e.g. A common framework for agriculture and land use in the nationally determined contributions aims to support NDC planning processes and needs in the AFOLU sector specifically (Crumpler *et al.*, 2020). In countries where peat extraction is a reality, such as for industry, horticulture and/or energy, those sectors need to be engaged for a holistic approach for phasing out the use of this fossil resource. Aligning NDC with a country's other national, regional and international commitments in the planning phase can also facilitate measurement and reporting processes, reduce duplication and increase efficiency (UNDP, 2017; FAO, 2020).

3.4 THE TRANSPARENCY FRAMEWORK

The Enhanced Transparency Framework (ETF) aims to provide a clear understanding of climate change actions and support and is a foundation of the Paris Agreement. Designed to promote transparency and mutual trust, the framework is based on existing transparency arrangements set up under the UNFCCC, commonly known as the measurement, reporting and verification (MRV) framework (Figure 13). The Katowice Climate Package has provided the rulebook for implementing the ETF, known as modalities, procedures and guidelines (MPGs) in decision 18/CMA.1 and the guidance for operationalizing the MPGs in decision 5/CMA.3. Under the ETF, Parties are required to submit their first biennial transparency report (BTR), which replaces the previous biennial update reports, and national inventory report by 31 December 2024. BTRs will be an important input into the global stocktake. As part of the overall cycle of ambition, the ETF may be tailored towards sectors that may significantly contribute to emission reductions and carbon sequestration. It should also facilitate investment and financial flows to support the associated conservation and restoration actions. The ETF Reference Manual, prepared by the UNFCCC, provides key guidance and recommendations on capacity building for transparency and reporting are also available (UNFCCC, 2022b).

© Greifswald Mire Centre/H. Joosten

Figure 13 **Moving from measurement, reporting and verification towards the transparency framework**



Legend: MRV = measurement, reporting and verification; ETF = enhanced transparency framework.

Source: **UN Climate Change.** 2021. *How to prepare for the transition from MRV framework to the ETF.* Webinar presentation on 6 October 2021. Cited 30 August 30. www.youtube.com/watch?v=F8Q-XqDaAkw

Transparency of action refers to information that each country must provide regularly to enable an understanding of its climate change actions. These include, for example, the national greenhouse gas inventory and indicators to track progress in implementing its NDC, as well as information related to climate change impacts and adaptation. Transparency of support refers to clarity on the support provided and received related to mitigation, adaptation, finance, technology development and transfer and capacity development. The UNFCCC decision further states: "Developed countries shall, and other Parties that provide support should" (...) "submit information on FTC (NB: financial, technology development and transfer, and capacity-building) support provided and mobilized to developing country Parties in implementing the Paris Agreement.", while "developing country Parties are encouraged to communicate any support that they need and have received" (Decision 18/CMA.1; see also: UNFCCC, 2022b).

The Paris Agreement called for the establishment of a Capacity Building Initiative for Transparency (CBIT) trust fund administered by the Global Environment Facility (GEF). This initiative aims to help strengthen the institutional and technical capacities of developing countries to meet the ETF requirements. As reported by the GEF, in many developing countries, the AFOLU sector is responsible for over half of total GHG emissions and presents challenges in the quantification of GHG emissions/removals, due to inadequate systems and tools to measure, collect, and monitor data; weak institutional arrangements; and insufficient human resources. Two global CBIT projects CBIT-Forest and CBIT-AFOLU, led by FAO and partners, address critical data collection and reporting challenges related to these sectors. Experiences and lessons learned on open data and transparency are available in a publication launched in 2022. Resources, tools, eLearning material and cases studies are available in the FAO's Climate Change Knowledge Hub.

Under the ETF, robust data collection is the basis for reporting on emissions and removals[1] and tracking NDC progress. For peatlands, the "2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands", also known as the Wetlands supplement, acts as the guiding document to report on emissions and removals from drainage and rewetting of organic soils (i.e. peatlands managed for forestry, cropland and grazing land, and peatland rewetting). It includes GHG emissions from fires and carbon dissolved in water. For guidance on peat extraction sites, the main methodology remains the IPCC 2006 Chapter on Wetlands. For peatlands converted to permanently flooded land, the IPCC 2019 refinement is the currently applicable guidance document.

Preparing monitoring systems

A key mechanism to boost transparency and accountability is the development of a national monitoring framework. Within this framework, different monitoring efforts, such as the National Forest Monitoring Systems (NFMS), are nationally defined procedures to observe specific variables and their changes regularly and systematically over time. They contribute to data collection and measurements, reporting and verification with the goal to produce high-quality and reliable data. They can support policy frameworks, management actions and the sustainable development of territories with peatlands. The assurance of data availability and access are essential to establish transparent baselines, inform policies, and facilitate reporting (NDC Partnership, 2021).

A key first step is the adaptive planning, creation, or integration of monitoring systems that include peatlands.

The definition of "wetlands" contained in Article 1 of the Ramsar Convention on Wetlands also encompasses all peatlands. National Wetland Inventories prepared by parties to the Convention support monitoring and assessment, planning and decision making as well as reporting on peatlands. These can be an important source of data. The resolutions of the Conferences of Parties to the Convention on Wetlands call on parties to further develop their National Wetland Inventories, and to use these for defining peatland actions in NDCs. Particularly, the Resolution XII.11 encourages Contracting Parties to utilize their inventories to map the distribution of peatlands with a view to determining the extent to which they sequester carbon. Similarly, the Resolution XIII.12 provides guidance on identifying peatlands as Wetlands of International Importance (Ramsar Sites) for global climate change regulation as an additional argument to the existing Ramsar criteria.

For some countries, the limited knowledge on peatland area, location and functioning pose a challenge to include peatlands in national monitoring systems and climate commitments. National governments should therefore work with relevant ministries and agencies to develop a national peatland map or complement it. Institutions and stakeholders can use a peatland map layer for territorial and land-use planning, management and conservation efforts. Academia and governments are also encouraged to collaborate on the definition of soil carbon content and the minimum thickness necessary to define a peatland (FAO, 2020).

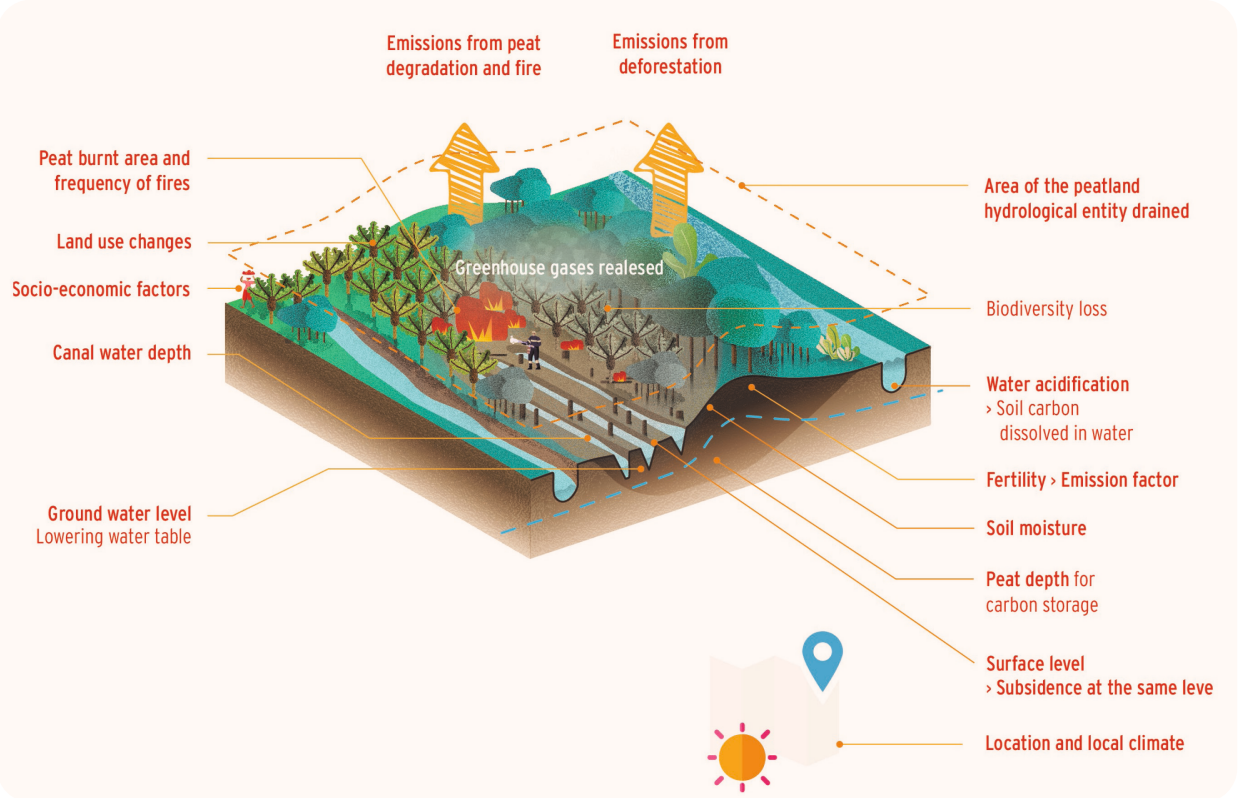
A robust monitoring system can enable the evaluation of policy implementation and climate action. A key first step is the adaptive planning, creation or integration of monitoring tools, ecological, agriculture and energy data and information that cover territories with peatlands. An existing national forest monitoring system can also support a variety of land use planning and reporting requirements (FAO, 2020). This can help fulfil the need to develop, monitor, and report on forest resources, which may include various land cover classes and soil types, such as peatlands (FAO, 2017). Monitoring systems can support efforts to secure multiple ecosystem services provided by peatlands within a vast landscape that includes multiple stakeholders and peatland-dependent communities. A targeted and user-friendly monitoring procedure should be supported by cost-effective, robust and handy tools operable with minimum technical skills and resources.

Local communities can also play a role in peatland mapping and monitoring, e.g. to identify potential peatland areas, map boundaries and management activities. Involving communities from the start should encourage a two-way learning approach where experts can better understand and measure the value of peatlands at the same time that communities' capacities on sustainable peatland management are enhanced.

The Peatlands mapping and monitoring report (FAO, 2020) gives an overview and concrete examples of tools, approaches and reasons for peatlands' integration into national forest monitoring systems, including key data required to monitor peatlands of different status (i.e. pristine, degraded, restored). Key variables required for monitoring a drained peatland with canals are represented in Figure 14.

1 Decision 18/CMA.1 - Annex Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement: Chapter II National inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases. Section C paragraph 20 (FCCC/PA/CMA/2018/3/Add.2)

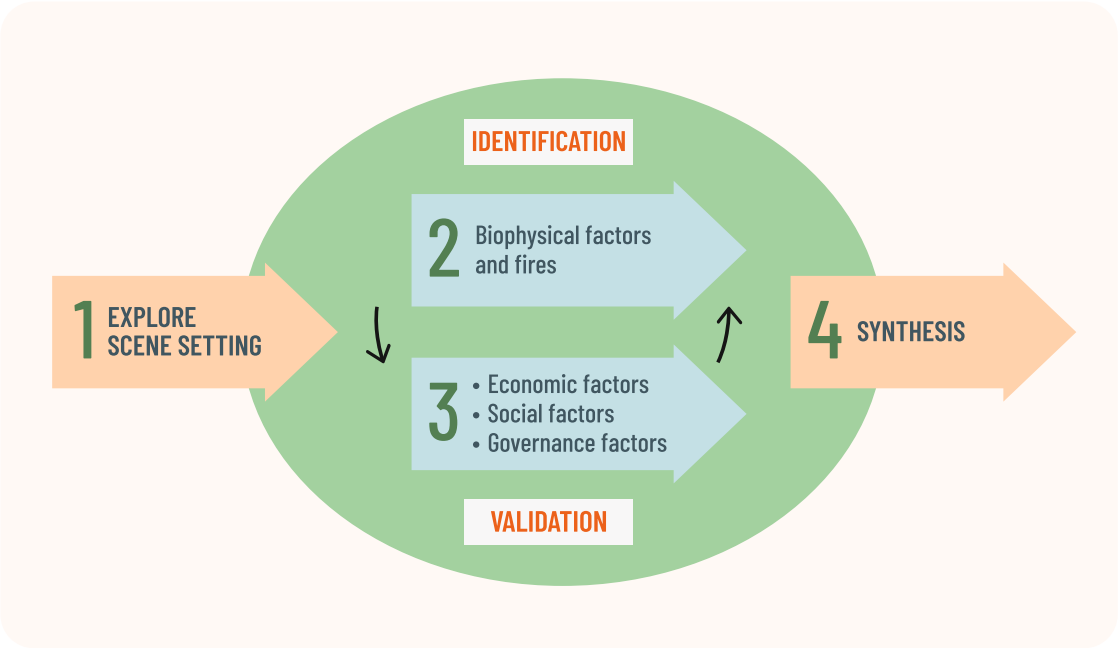
Figure 14 **Data needed for monitoring drained peatlands**



Source: **FAO**. 2020. *Peatland mapping and monitoring Recommendations and technical overview*. Rome. www.fao.org/3/ca8200en/ca8200en.pdf

Climate action, as committed in a country's NDC, can be evaluated by its effectiveness (i.e. level of success in producing the desired result), efficiency (i.e. capacity to achieve results with little or no waste of resources) and equity (i.e. just and impartial to all stakeholders) (Bhomia and Murdiyarso, 2021). The use of criteria and indicators should enable the evaluation of the actions proposed. As an example, Figure 18 highlights the process followed to identify principles, criteria and indicators for peatland restoration, and could be adapted for other management goals. Criteria and indicators for this example are classified under four key categories, namely, technical/biophysical, social, economic and governance aspects.

Figure 15 **Example to identify principles, criteria and indicators for peatland restoration**



Source: **Bhomia, R.K. & Murdiyarso, D.** 2021. *Effective monitoring and management of peatland restoration*. Working Paper 270. Bogor, Indonesia, CIFOR. www.cifor.org/publications/pdf_files/wpapers/wp270bhomia.pdf

A national registry system for GHG inventory should be established and harmonized to ensure transparency for UNFCCC reporting and facilitate the avoidance of double counting of GHG emission reductions. Likewise, national and international climate change policies should take measures to avoid carbon leakage. Leakage is defined by the European Commission (2022) as a situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries with more lax emission constraints. This could lead to an increase in the total emissions.

Expert judgement is often required to rate the credibility of emissions reduction, social acceptance, and economic viability of a project. Independent analysts, such as Climate Action Tracker, may challenge and encourage Parties to improve governance, policy and action and their analysis is worth noting.

Early warning, early action

Early warning, early action features may be increasingly necessary to assess risks facing peatlands and can be integrated into national forest monitoring systems. Peatland flooding due to subsidence of drained peatlands, combined with rising seawater levels and changing rainfall patterns, together with peatland fire monitoring and early warning is often a priority for countries.

Peatland drainage significantly increases the risk of fire. Peat fires, that is: smouldering fires in the peat soil layer, are difficult to detect and extinguish, and may last for weeks and up to months, even during extensive rains (Joosten and Clarke, 2002). Peat fires have been associated with large numbers of premature human deaths from respiratory illnesses and large economic losses as a result of air pollution from haze (Koplitz *et al.*, 2016).

Peat fires, that is: smouldering fires in the peat soil layer, are difficult to detect and extinguish, and may last for weeks and up to months, even during extensive rains.

Early warning systems can estimate the likelihood of catastrophic events, hours, days, weeks, months or years in advance before they occur. They enable forest and land management agencies, landowners and communities to prepare responses to the threats and reduce environmental, health and socioeconomic impacts. An integrated early warning system for peatland ecosystems, focusing on fire prevention, will contribute to reducing emissions, peat losses, and the high costs of suppressing peatland fires.

Box 5

Fire-care community groups in Indonesia

Since mid-2020, Indonesia has made efforts to improve the MPA programs (i.e. Masyarakat Peduli Api – community fire awareness group or fire-care community) through training on forest and land fire control, laws and regulations, and the potential for diversification of economic businesses depending on the particular resources of each village. Community groups are empowered to carry out integrated patrols with ground-check hotspots, collecting data on water levels, and performing early suppression of forest and land (peat) fires. Furthermore, a programme on land preparation without burning (Pengolahan Lahan Tanpa Bakar, PLTB) has been implemented to encourage communities to engage in fire prevention, including activities such as paludiculture, charcoal briquetting from the residues from land clearing (wood, twigs, sawdust), and wood vinegar production to use it as a fertilizer.

Source: **Ministry of Environment and Forestry of Indonesia.** 2020. *The State of Indonesia's Forests 2020*.

Technological advances in satellite sensor design enable high spatial and temporal resolution in data collection, transmission, evaluation and analysis. This allows the forecast of weather anomalies such as rainfall and temperature that "deviate" from the mean model climate days or months prior to their occurrence and inform fire readiness to reduce risks. The Global Wildfire Information System (GWIS) early warning system produces forecast maps to identify periods of increased fire danger from 1–9 days to up to six months in advance.

Fire managers can use early warning systems to indicate the upcoming peatland fire season potential, including efforts needed for fire readiness in every season. The persistent occurrence of peat fires in Indonesia since the 1980s has led to the development of Fire Danger Rating Systems (FDRS) (Dennis, 1999). These systems monitor fires for effective national and regional fire management. Indonesia's efforts in developing a more effective, systematic fire danger rating, early warning and early action system are commendable. Other countries facing looming peat fire threats are therefore encouraged to identify steps towards more comprehensive and effective fire risk-reduction strategies based on their local conditions.

Globally, more than 95 percent of all forest – and peat – fires are caused by humans, directly or indirectly, deliberately or due to carelessness (WWF, 2017). Thus people, and particularly communities living in peatland areas, can play a significant role in fire management. Communities use fires to clear the land to cultivate crops, and they can detect, prevent and early suppress fires that have a detrimental effect on their lives. Community-based fire management can be a cost-effective way to prevent peat fires, especially when communities have a sense of ownership, meaning that they have an active role in decision making for meeting their needs and management objectives, instead of merely participating for paid labour (Ganz and Moore, 2002). Integrated fire management approaches that build on existing social structures and involve traditional leadership, together with an enabling environment (i.e. supportive legislation) and awareness raising are likely to be more socially and economically sustainable (Goldammer *et al.* 2002).

To support countries in effectively managing their fire risks, a new FAO-UNEP initiative, "Global Fire Management Platform" was announced during the Fire Management Forum in May, 2022 at the World Forestry Congress, in Korea. The platform will aim to reduce the negative impacts of wildfires on livelihoods and landscapes while ensuring global climate stability.

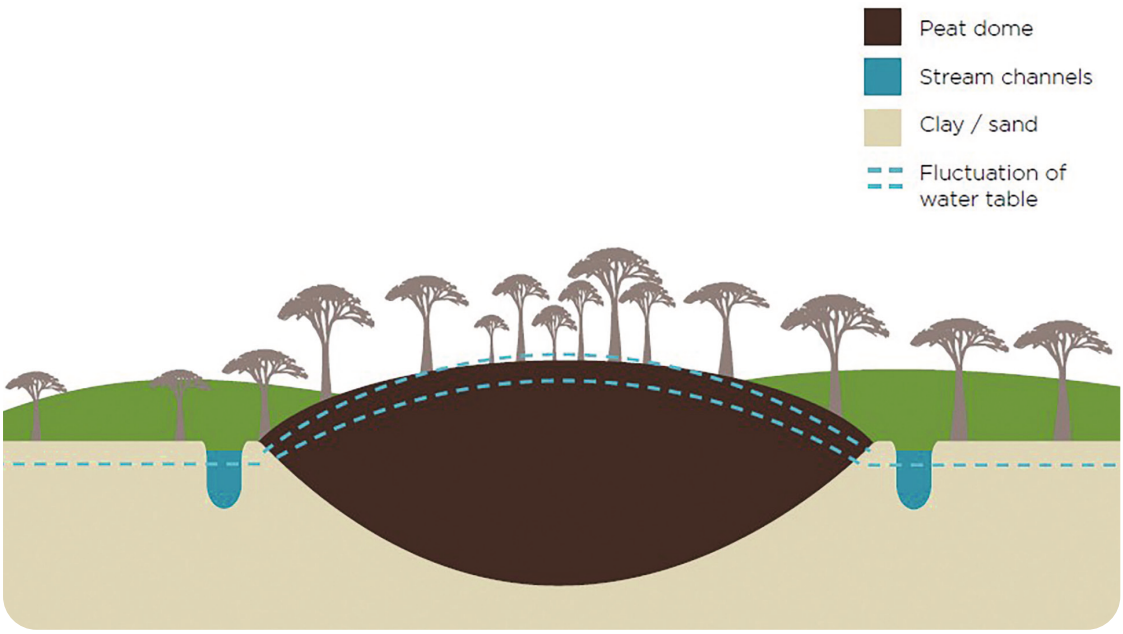
3.5 KEY PEATLAND OPPORTUNITIES

As illustrated in previous chapters, peatlands play a vital role in reducing and avoiding GHG emissions, reducing disaster risks, enhancing resilience and climate change adaptation capacity especially through provision of ecosystem services. The potential of peatlands as nature-based climate solutions has recently been reviewed by Strack *et al.* (2022), highlighting the need to analyse and measure the effects of any proposed solution, also in the long-term. Improved peatland management may include actions to protect, conserve, restore and sustainably manage natural and modified peatland ecosystems. These actions should also address social challenges, support adaptation and resilience, and provide human well-being and biodiversity benefits (UNEP/EA.5/Res.5). Drainage-free land-use options are crucial to achieve climate goals and ensure long-term sustainable land-use. Importantly nature-based solutions, including peatland protection, restoration and management, cannot replace the rapid phase-out of fossil fuels and should not be used to delay decarbonization of economies (Strack *et al.* 2022).

As outlined earlier in Chapter 2 Peatlands' contribution to climate action, peatland ecology determines that any change in a peatland's hydrology (i.e. water), its peat and/or its vegetation will affect all other components. Figure 16 shows a representation of a tropical peat dome

with peat swamp forest and freshwater swamp forests at the margins, where the water table will be at or above the peat surface for much of the year, with limited drawdown during the dry season. Activities such as drainage, deforestation and other forms of land degradation that impact or break the balance should, therefore, be avoided. There are different peatland-related strategies that may be considered to bolster landscape resilience and secure ecosystem services provision, as analysed with examples in the following sections.

Figure 16 **Representation of a tropical peat dome**



Source: **Page, S. E., Morrison, R., Malins, C., Hooijer, A., Rieley, J.O. & Jauhiainen, J.** 2011. *Review of peat surface greenhouse gas emissions from oil palm plantations in Southeast Asia*. Washington, DC, International Council on Clean Transportation (ICCT).

Peatland conservation

For a country with pristine peatlands, the most cost-effective strategy to avoid carbon losses and maintaining other ecosystem services (including those related to water and resilience) is to protect and conserve these areas. Conservation or protection means refraining from all actions that disrupt natural ecosystem functions, such as drainage, fertilizing, tree cutting, slash and burn management, infrastructure development. Non-invasive livelihood activities (e.g. collection of food, fibre, feed and fuel, small-scale livestock rearing, and ecotourism) can be consolidated with peatland conservation (FAO and ITPS, 2021).

Peatland assessment or "inventory" is the first step to identify areas important for the conservation of biodiversity and/or climate benefits. Also outside conservation areas, it is necessary that the ecosystem services provided by peatlands are identified and considered in land-use planning. It is recommended to quantify these services, to the extent possible (Barbier and Burgess, eds., 2021) as a justification for resource allocation. The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative assessing the costs of the loss of biodiversity and the associated decline in ecosystem services worldwide. Likewise, the System of Environmental Economic Accounting (SEEA) adopted by the United Nations Statistical Commission, developed the SEEA Ecosystem Accounting as an integrated and comprehensive statistical framework to organize data, measure ecosystem services, track changes and link this information to economic and other human activity. It is built on five core accounts which are compiled using spatially explicit data and information on ecosystem assets and ecosystem services. The framework has already been used to inform policy development in more than 34 countries (SEEA, 2022).

The Global Peatlands Initiative pursues the conservation of all pristine peatlands globally, requiring most urgent action in regions with high pressure of peatland drainage and/or vegetation alteration. Financing options are available also for conservation (see 3.7. FINANCING

PEATLAND ACTION) and combined with benefits from ecosystem services these may exceed income from other, destructive activities. Similarly, the UN Decade on Ecosystem Restoration highlights both peatland rewetting and conservation as key areas of attention.

For a country with pristine peatlands, the most cost-effective strategy to avoid considerable GHG emissions and to maintain ecosystem services is to protect and conserve these areas. [...] A peatland assessment or inventory is often the first step to advance.

As an example of a consolidated conservation and recreational use of a national park with peatlands, in Southern Finland, the Torronsuo National Park (Figure 17), is the deepest peat bog in the country. Following national law and its "The Everyman's Rights" (jokamiehen oikeudet), anyone has the right to forage berries and mushrooms, fish with a line and rod, and enjoy the recreational use of the area (Visit Finland, 2022). The park offers visitors duckboard trails and opportunities to admire the biodiversity through bird watching towers. Both public awareness raising and allowing access to natural resources are in line with the principles of the Ramsar Convention on Wetlands.

Figure 17 **Landscape of the Torronsuo national park**

© FAO/Elisabet Rams Beltrán

© FAO/Elisabet Rams Beltrán

The law permits also lighting campfires in dedicated areas within the conservation area, though only outside the periods of high forest fire danger, which are announced daily in national and local media. The Finnish Meteorological Institute calculates and communicates the risk based on data on temperature, humidity, wind, rainfall quantity and strength in open landscapes for each province. The Regional State Administrative Agency is tasked to monitor the incidence of fire, whereas police and park authorities have the right to sanction illegal fire use (Finlex, 2011).

Peatland restoration

Peatland restoration can be included in climate action as a synergistic effort supporting both mitigation as well as long-term adaptive capacity and resilience. Restoration measures should be targeting areas where peatlands have been impacted by agricultural expansion, peat extraction, forest plantations or other types of peatland degradation. The resolution XIII.13 of the Parties to the Convention on Wetlands encourages Parties to restore degraded peatlands to mitigate and adapt to climate change and enhance biodiversity and disaster risk reduction.

Rewetting of drained peatlands effectively reduces the overall GHG emissions by largely stopping the decomposition previously caused by the drainage. Although rewetting also re-establishes methane

© Greifswald Mire Centre/H. Joosten

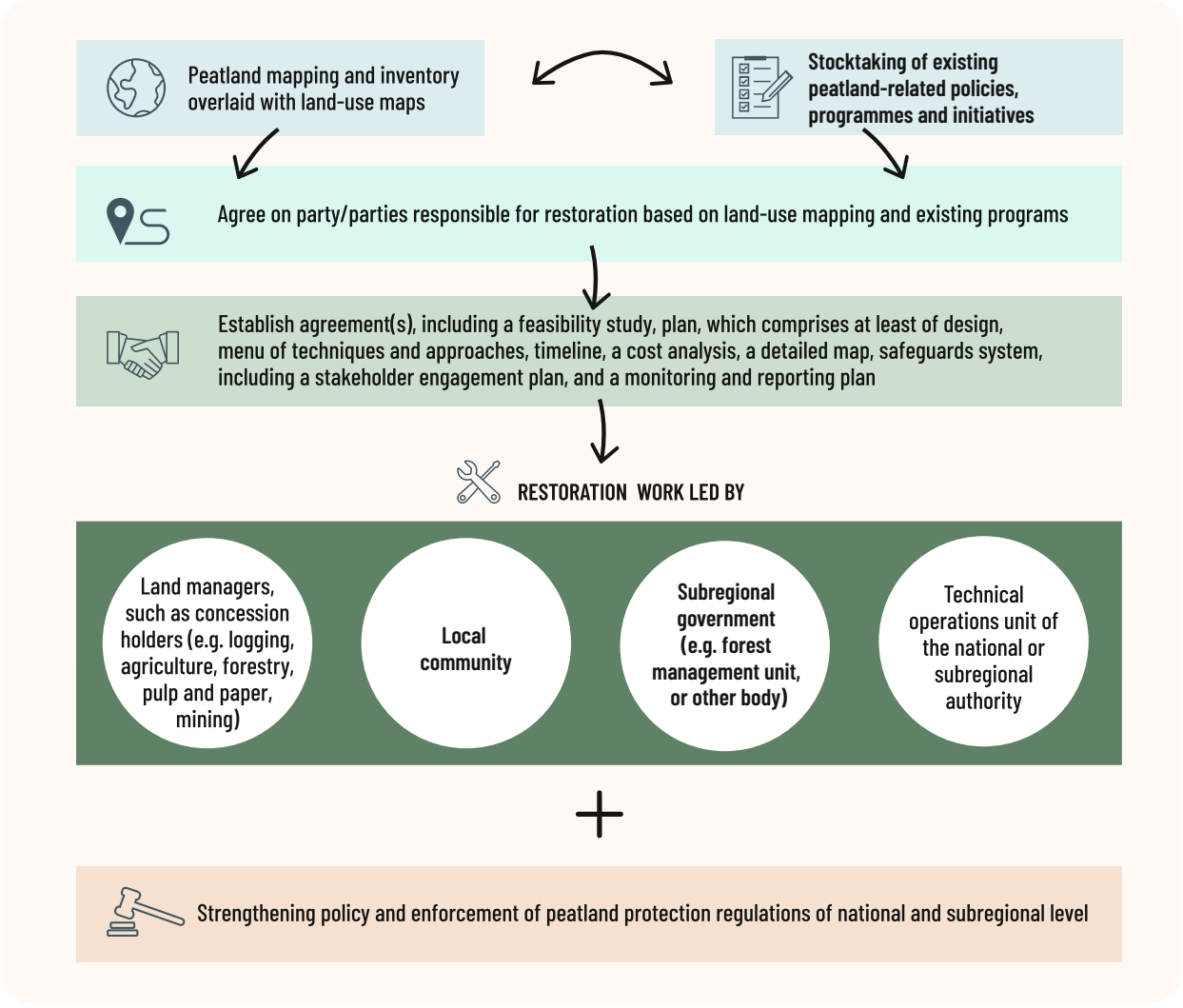
emissions (CH_4) – a strong but short-lived GHG – the recent study by Günther *et al.* (2020) clearly shows that methane emissions do not undermine the climate change mitigation potential of peatland rewetting. The study also highlights that postponing rewetting would increase the long-term warming effect of continued CO_2 emission – a weaker but persistent GHG.

Restoration mitigates climate change and may also support the reduction of flood and fire risk. Studies have shown that peatland restoration in Sumatra and Kalimantan (Indonesia) would reduce forest- and land-fire risks by 6–37 percent and 26 percent of the total, national emissions from land use (Tan *et al.*, 2022). Restoration activities need to consider the existing land-use practices and tenure rights, and aim to ensure livelihoods and food security of the local communities.

Rewetting of drained peatlands effectively reduces the overall GHG emissions by largely stopping the decomposition previously caused by the drainage. (...) Restoration activities need to consider the existing land-use practices and tenure rights, and aim to ensure livelihoods and food security of the local communities.

Peatland restoration criteria and indicators depend on the objectives of restoration and must guide the key data required to measure restoration progress over time. They should cover biophysical, social, economic, and governance aspects (Bhomia and Murdiyarso 2021). Figure 18 represents the approach to peatland restoration as undertaken by Indonesia's Peatland Restoration Agency.

Figure 18 Approach to peatland restoration



Source: Adapted from **Wardhana B.** 2016. *BRG's Roadmap for peatland restoration*. Workshop presentation in May 2016. Indonesia.

The recently published peatland restoration guidance of the Convention on Wetlands (2021a, b, and c: Global guidelines for peatland rewetting and restoration, Briefing note on practical peatland restoration, and Policy brief to restore drained peatlands, all also available in French and Spanish) comprise an excellent compilation of the latest science-based information on peatland restoration.

Food security

While many food production approaches with dryland species are detrimental both to people and to the peatland ecosystem, there are many traditional and innovative approaches that also support food security in the peatland landscapes. Peatlands offer important provisioning services of food, feed and fibre that support communities' resilience and adaptive capacity.

Common products supporting food security include fish, game and fruits, berries, mushrooms, roots, and medicinal plants. In the Peruvian Amazon, the harvesting of "aguaje"' fruit (*Mauritia flexuosa*) is an important income-generating activity and source of food for the local communities (Virapongse, 2017). Aguaje fruit is one of the most celebrated cases of nutritious food products with existing value chains. Aguaje products are widely available also in online stores, and a project supporting the permanent tree-cover to the peatland by conservation of aguaje-producing trees was accepted by the Green Climate Fund as one of its first projects (Green Climate Fund, 2015).

In Indonesia, for many people fishing in peatland catchments is the main source of income (Hergoualc'h *et al.*, 2018). The "beje" is a traditional fishing method in tropical peat swamp forests, which provides an important source of food and can also act as an efficient fire-break (FAO, 2015b; Adinugroho *et al.*, 2005). The method relies on fluctuations in the movement of water or overflow of river water during the rainy season (November to March) by using a trap in the form of an artificial pond or special tools. This allows fish to breed in the pond and later to be harvested during the dry season when the water recedes (April to October). Approximately 5-12 species of fish are caught in beje, dominated by marsh fish (black fish) from the family Anabantidae and Nandidae (FAO, 2015b). Indonesian stakeholders are exploring the beje approach further, as documented in the FAO (2015c) practice brief.

Enhanced water management solutions, such as producing more food while using less water, and building the resilience of farming communities to cope with floods and droughts, also increase food security by safeguarding peoples' sustainable access to adequate quantities of acceptable quality water.

Water

Maintaining high water tables and peat-forming vegetation will contribute to securing ecosystem services related to water supply and quality and regulation of flows in peatland watersheds. A study showed that peatlands provide water to 71.4 million people globally (Xu *et al.*, 2018). More research is however needed to more accurately define peatland's contribution to drinking water supply.

Peatlands, like many other wetlands, have also been used for extraction of water for irrigation. This practice is likely to increase with the increasingly erratic rainfall and hotter temperatures. Irrigation water extraction will, however, also drain peatlands, and affect their adaptive capacity and increase risk of fires. In countries where irrigation water extraction from peatlands is being practiced, stopping this practice could qualify as a climate change mitigation measure (*Convention on Wetlands 2021d, 2021e*).

Páramos are a mountain ecosystem in the Andean mountains - with occurrence of peat - situated above the tree line and below glaciers. This ecosystem is crucial for supplying water for agriculture in inter-Andean valleys, hydropower and high and low-altitude cities, including Quito (Ecuador), Bogota (Bolivia) and Lima (Peru). Some of these peatland areas contributing to drinking and/or irrigation water have a centuries-long history of overgrazing.

Enhanced water management (..) increases food security by safeguarding peoples' sustainable access to adequate quantities of acceptable quality water.

In Ecuador, efforts have been undertaken to conserve and restore water-related environmental services including removal of all sheep and cattle on around 20 demonstration plots to test various techniques, such as simple fencing and the transplantation of plants from well-conserved nearby areas. A monitoring framework was also put into place by the government to measure the hydrological benefits of the restoration activities on future water supply (FAO, 2015a). Other cases of peatland restoration for enhanced water security have included the improvement of grazing land practices (e.g. in Mongolia, and in the United Kingdom of Great Britain and Northern Ireland, see e.g. FAO, 2012).

Sustainable livelihoods and income generation activities

Certain local livelihoods depend on healthy peatlands, therefore sustainable peatland management, as well as enhancing and supporting local livelihoods that contribute to zero-drainage is necessary. Sustainable peatland management practices - compared to drainage-based activities that eventually create abandoned and unproductive land (Ewert and Abel, 2021) - are needed to secure

livelihoods of local communities in the long term and, in some cases, income-generating activities to support local economies. Capacity development for the development of drainage-free practices is key for planning effective strategies and have local support by raising awareness, as well as supporting alternative livelihoods.

An understanding of the impacts of different management practices at the local level and those downstream or surrounding the peatland is key to formulate realistic targets for including peatlands in the low-carbon development pathway. Particularly relevant is knowledge of the impacts on land subsidence and erosion, GHG emissions, water security and quality, biodiversity and other ecosystem services. FAO has collected various case studies from around the world that describe practices related to peatland rewetting, wet biomass production, degraded pasture restoration, forestry practices and fisheries (FAO, 2020).

Drainage-free activities also support long-term adaptive capacity of different stakeholder groups – as they protect the peatland body from land loss, fires, erosion, etc – by securing long-term solutions that will ensure communities resilience to climate change. Stakeholders can be supported with capacity development and financial support to develop income-generating and drainage-free practices. The support in the spirit of climate justice can, with time, facilitate the transition from drainage-based activities (e.g. mining, peat extraction, cultivation of palm oil, pineapple, aloe vera, acacia, etc) to those that allow long-term cohabitation with wet peatlands, such as paludiculture. In the context of climate change, land degradation, and loss of biodiversity, agricultural and forestry activities need to prioritize sustainable economic development towards the Sustainable Development Goals and consider the costs and benefits of different activities for the different stakeholder groups, especially those whose livelihoods directly depend on the well-functioning of peatlands. Such activities should be integrated into long-term strategies, disaster risk management actions and social protection programs (FAO, 2022).

Box 6

Paludiculture and examples in Southeast Asia

Paludiculture is the sustainable cultivation of swamp species on wet or rewetted peat, with the groundwater level at or near to the surface. Paludiculture uses species and techniques that enable selected plants, trees and/or animals (including fish, bees) to be grown in wet and rewetted peatlands (i.e. with a near-natural or restored hydrology). This provides conditions that maintain the peat body, sustain livelihoods and ecosystem services and can help reduce GHG emissions and reduce fire risk. Paludiculture can be considered a responsible, long-term management option for peatland management. When paludiculture is introduced for the first time in a country or region, it is of upmost importance to have a clear and evidence-based definition to prevent its misuse.

An assessment of Southeast Asian swamps identified 534 peat-swamp plant species with known uses (e.g. timber, medicines and food), of which 81 were defined as to have a major economic use.[a] Examples of wetland species that have been used for generating income include: *Metroxylon sagu* (sago), *Illipe* species or *Shorea* spp., *Channa* fish spp., *Calophyllum inophyllum* (*Nyamplung* spp.), *Melaleuca* cajuputi (gelam), *Dyera polyphylla* (jelutung spp.), *Eleocharis dulcis* (purun or water chestnut), *Aleurites moluccana* (kemiri or candlenut), and others. For further information see for example, the Greifswald Mire Centre's Database of Potential Paludiculture Plants and Giesen and Sari, 2018[b] (see next section).

Combination of different livelihood sources can also help overcoming barriers for adoption and allow income generation for example while waiting for species to grow. For the overall sustainability, attention should be given in the usage of native, locally-adapted species that grow on wetlands to avoid serious issues caused by invasive alien species. Certain practices, such as aquaculture, require sustainability assessments in all cases.

Illipe nut (*Shorea stenoptera*) is a Southeast Asian climax forest tree. In terms of GHG emissions, illipe tree cultivation with high water levels is neutral. Illipe nuts are an important non-timber forest product with a high commercial value. The fat derived from the nuts is used in chocolate and similar products. The tree also produces quality timber for plywood face-veneer.[c]

Notes: a **FAO.** 2014. *Towards climate-responsible peatlands management*. Rome. www.fao.org/3/i4029e/i4029e.pdf

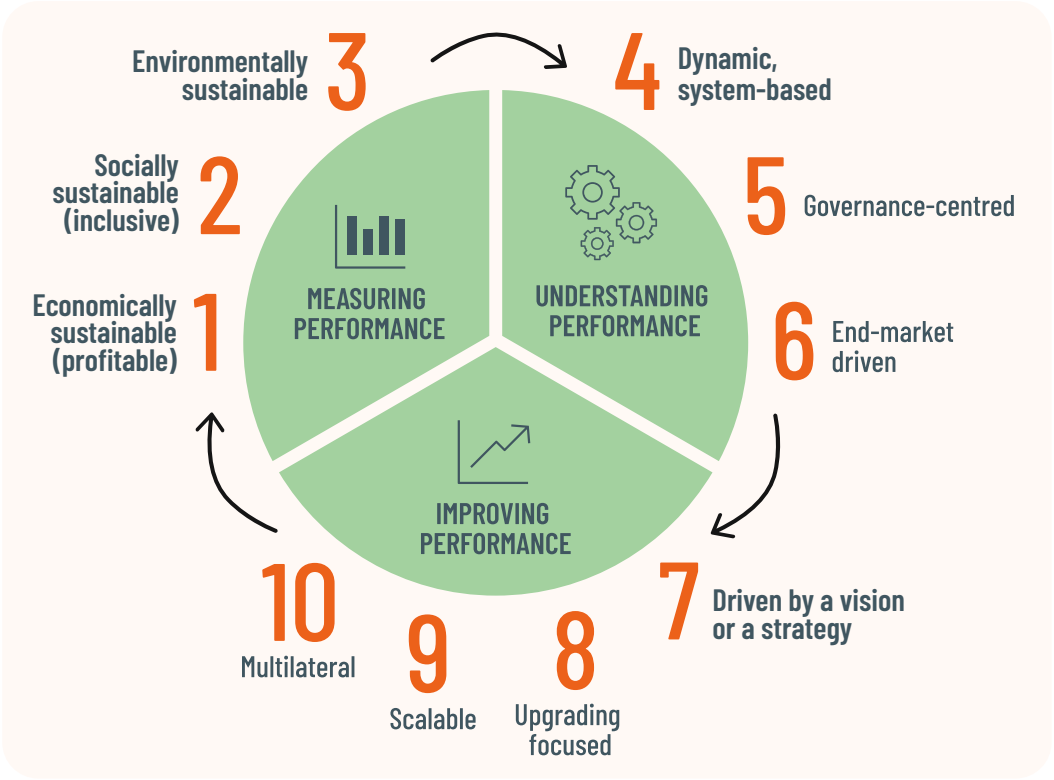
b **Giesen, W. & Sari, E.N.** 2018. *Tropical peatland restoration report: the Indonesian case*. 10.13140/RG.2.2.30049.40808.

c **FAO**. 2015. *Illipe nut plantation on undrained peatland.* Practice case 4415E/1/02.15. www.fao.org/3/i4415e/i4415e.pdf

Value chains and access to markets

To support communities' resilience in peatland landscapes, more research but also investment in practical efforts, such as feasibility studies, to develop livelihoods is needed to upscale sustainable livelihood and income-generating options worldwide and, in particular in the tropics. Giesen and Sari (2018) and the Greifswald Mire Centre (with its Database of Potential Paludiculture Plants) have systematically mapped existing wet management practices for different climatic zones, with the main recommendation that investment should target, in particular, generation of viable and sustainable value chains.

Figure 19 **Principles of sustainable food value chain development**



Source: **FAO**. 2014. *Developing sustainable food value chains: Guiding principles*. Rome. www.fao.org/3/i3953e/i3953e.pdf

Sustainable livelihoods on peatlands can only be successful through engagement of key stakeholders, improvement of associated value chains and technical knowledge for high productivity to render these commodities more financially attractive (Hergoualc'h *et al.*, 2018). An example of guiding principles of sustainable food value chain development can be seen in Figure 19.

Indigenous Peoples and traditional ecological knowledge

Traditional ecological knowledge has proven to help local communities to observe and respond to local climate change. Traditional knowledge helps Indigenous communities to adapt to climate risks and promotes social and ecological resilience. This upholds social empowerment and sustainable resource management (Hosen *et al.*, 2020). Indigenous Peoples' territories cover a quarter of the world's land surface (FAO *et al.*, 2021) and contain 80 percent of the earth's remaining healthy ecosystems and global biodiversity priority areas (Sobrevila, 2008). By sustainably managing their territories, through their traditional knowledge, Indigenous Peoples have protected related ecosystems and biodiversity for many years.

Scientists and traditional and Indigenous knowledge holders in Finland are collaborating to rewild and protect peatlands and associated forests and rivers. They aim to turn them into carbon sinks again,

while also bringing back wildlife and supporting fishing, hunting, and even tourism, offering economic benefits to local communities (Palmer, 2022).

The Indigenous Peoples of Borneo – the Dayak communities – have contributed to some extent to the sustainable use of the peatlands they live in. Locals have continued preserving a rotating farming system, which maintains a certain balance between the utilization and the natural cycle of the land (Suwardi *et al.*, 2005). The land is divided into different areas of use, including sacred zones and protected zones. Sacred zones are customary protected zones that should not be cleared for agricultural land. Drainage is limited to one access way and peat areas are used for subsistence only and conducted sustainably (Ministry of Environment and Forestry, 2018).

Traditional ecological knowledge helps indigenous communities adapt to climate risks and promotes social and ecological resilience.

3.6 TOOLS TO SUPPORT INTEGRATION

To materialize these opportunities, countries are encouraged to use tools that optimize the information available and support climate change mitigation actions and policy planning. Examples of such tools include:

The Nationally Determined Contribution Expert Tool (NEXT) is a GHG accounting tool developed by FAO to support annual environmental impact assessment for the AFOLU sector. The tool supports the tracking of NDCs through providing a high temporal series of results and a wide set of indicators, allowing a comprehensive environmental and economic overview of climate actions to achieve a mitigation target. The tool also helps countries interpret, track and scale up ambition of their NDCs, which could ultimately feed into and inform the global stocktake of the Paris Agreement in a harmonized way (FAO, 2022).

The NDC Partnership Climate Toolbox includes tools, guidance, platforms and advisory support from leading institutions. The searchable database aims to help countries plan and implement their NDCs. The Toolbox is designed to aid government officials, implementing partners, and any other parties working on NDC planning and implementation. The toolbox is user-friendly and a Support Unit is provided.

The Learning tool for Nationally Appropriate Mitigation Actions (NAMA) in the AFOLU sector, published in 2015 by FAO in three languages, contains various modules to support identification and prioritization of GHG reduction options in a holistic way. The tool displays interventions to overcome barriers and presents available sources of data and finance options. Even if the NAMA as an instrument would not be applied, the document in slide format can be used to better understand sectoral specificities, challenges, opportunities and good practice also related to peatlands.

3.7 FINANCING PEATLAND ACTION

As stated by Günther *et al.* (2020): "to reach climate-neutrality in 2050, it is not sufficient to focus rewetting efforts on selected peatlands only; instead CO_2 emissions from (almost) all drained peatlands have to be stopped by rewetting." Effective financial frameworks, policies and actions are needed to restore virtually all drained peatlands worldwide to allow peatlands to fulfil their natural role as a global carbon sink (Convention on Wetlands, 2021c). Given the widespread drainage-based peatland management, it is evident that peatland ecosystem services are often undervalued. This lack of value leads to the current widespread underinvestment in peatland conservation, sustainable management and restoration at a global level.

Decision-makers may better target their climate actions if different funding sources are analysed at the early stages of NDC planning. Planning should also include a dialogue with all relevant stakeholders (including local and Indigenous communities and private sector actors) and an analysis of the potential activities to be implemented. Funding may come from increased taxes, decreased subsidies, results-based payments for REDD+, payments for ecosystem services (PES), sustainable value chains and carbon markets, among other sources.

Carbon markets could provide additional funds that contribute to sustainable peatland management. There is some contention on whether carbon markets can genuinely reduce GHG emissions at the national or global level, especially if focused on project-based action. Such contention makes it all the more important for countries to approach carbon market funding opportunities strategically to establish whether engagement is seen as desirable and contributing to national development objectives. Where countries do wish to engage, they will typically need to establish a set of systems and regulations to do so in a purposeful way. Countries should establish a national policy that, among other things, establishes what kinds of carbon market-related activities are seen as beneficial. A national registry system should be established that facilitates the avoidance of double counting of GHG emission reductions and that could help carrying out the corresponding adjustments against domestic mitigation targets should this be needed – e.g. when carbon credits are used to offset emissions from abroad. Countries will also need to work through legal aspects relating to the ownership of carbon aspects and associated benefit sharing arrangements.

Domestic financing for peatlands

Stakeholders working on peatlands may obtain domestic financing from public climate and environmental budget lines and private

investments (Table 8). Countries are recognizing the importance of wetlands and peatlands management for climate action. The rewetting of peatlands is included as a mitigation action in some new and updated NDCs, and 55 percent of the adaptation components of the updated NDCs refer to observed and/or projected climate-related impacts on freshwater resources and ecosystems, including wetlands (Crumpler *et al.*, 2021).

Most countries' NDCs are unconditional (UNFCCC, 2021b), i.e. they will be financed by domestic resources. It is therefore important to start with a review of public resources options for climate action, for example, to implement a NAMA. Public financing reduces the investment risk and may, later, attract international and/or private sector financing (FAO, 2015a). Public financing should therefore, for any country, be the most important initial financing opportunity. Some countries are dedicating public funds to restore peatlands, through mechanisms such as the Nature for Climate Peatland Grant Scheme in the United Kingdom. Public resources can also be allocated to promote activities that help transitioning from peat use in energy, stop peatland conversion to cropland, and enhance sustainable grazing and forestry in peatlands, among others.

Public financing reduces the investment risk. (...) Public financing should therefore, for any country, be the most important initial financing opportunity.

Wealthy countries should increase public and private investment to improve peatlands management within their territories. They could also increase financial and technical assistance to low- and middle-income countries. The latter must set up appropriate policies, long-term plans and demonstrate MRV capacities to receive funding from the international community (Barbier and Burgess, eds., 2021).

Currently, most funding to conserve and restore peatlands comes from domestic sources (Barbier and Burgess, eds., 2021). However, in developing countries, such as Indonesia (Sari *et al.*, 2020) and the Nile basin countries (GIZ, 2019), most funding comes or is foreseen to come from public international financial support. Countries can increase their public funds for peatlands by 1) reviewing adverse subsidies, which assume a cheap value of peatland ecosystem services or no value at all, to eliminate these or even pay for activities that damage peatlands, if suitable monitoring and law-enforcement is available; and 2) establishing taxes for activities that damage peatlands (Barbier and Burgess, eds., 2021) .

To achieve the Paris Agreement goals, public funds need be complemented with investments from the private sector. Industries, supported by national regulations, could, for example, invest in the development of sustainable supply chains that support peatlands (Barbier and Burgess, eds., 2021). Enabling conditions to promote private investment in climate actions, including for peatlands, involve maintaining a stable political situation, providing incentives for investments such as soft loans and guarantees, eliminating barriers and demonstrating profitability and low investment risk (Avagyan *et al.*, 2015). Indirect financing, which is, financing not directed specifically to peatlands but focused on issues that could improve peatland management, such as landscape approaches, improved practices and generation of alternative incomes can attract private investments. For instance, the establishment of Peatland Hydrological Units in Indonesia (PHU) follows a landscape approach, which allows to develop income-generation opportunities around the restoration areas like paludiculture, plantations and capitalization of ecosystem services (Sari *et al.*, 2020).

© U.S. Forest Service International Programs/Eva McNamara

Table 8 **Domestic financing sources for climate action on peatlands**

Sources of financing	Scope	Examples	Opportunities for peatlands
Public financing: government budget	All countries	The Indonesian Environmental Fund Management Agency (BPDLH), The Scottish Peatland ACTION Funding	Projects and programs at a national and subnational level related to climate, biodiversity and water resources management. Tax increases and levies for activities that threaten peatlands (i.e. activities that involve drainage, deforestation or other forms of land degradation), as well as removal of perverse subsidies. Regulation of the private sector financing environment. Positive incentives to reward sustainable management of peatland landscapes.
Private/blended financing: **National and international industries operating in any country**	All countries	Tropical Landscapes Finance Facility, & Green Fund The Irish Peatland Conservation Council Grupo AJE drinks in Peru	Investment in zero-drainage supply chains. Added value of certified products. Use of biodiversity and carbon offsets for peatland restoration.

Sources: **Avagyan, A., Karttunen, K., DeVit, C., Rioux, J.** 2015. *Learning tool on Nationally Appropriate Mitigation Actions (NAMAs) in the agriculture, forestry and other land use (AFOLU) sector.* Rome, FAO. www.fao.org/3/i4642e/i4642e.pdf

Barbier, E.B. & Burgess, J.C. (eds). 2021. *Economics of Peatlands Conservation, Restoration, and Sustainable Management - A Policy Report for the Global Peatlands Initiative.* Nairobi, United Nations Environment Programme. https://wedocs.unep.org/bitstream/handle/20.500.11822/37262/PeatCRSM.pdf

Blended finance, which combines public and private financing, is a major opportunity to take action to restore or conserve peatlands over time which otherwise would not be financially viable. Interesting cases of blended schemes include the United Kingdom Peatland Code (Moxey *et al.*, 2021), the Tropical Landscapes Finance Facility in Indonesia (Hincks, 2021) and those promoted by the Global Environment Facility worldwide (GEF, 2019), which also promotes addressing climate and biodiversity matters jointly. Biodiversity offsets have been promoted by some organizations, and new opportunities could arise following the Post-2020 global biodiversity framework under the United Nations Convention on Biological Diversity.

Financing from international cooperation

International cooperation presents multiple sources of financing. The overview (Table 9), presents examples both from multilateral, bilateral as well as private funds and financing sources.

The UN Decade on Ecosystem Restoration (2021-2030) provides an additional opportunity to obtain financing from international cooperation sources. Peatlands are one of the key ecosystem restoration types highlighted by the Decade. The Decade's coordinating organizations, FAO and UNEP, will make annual calls to collect restoration flagship initiatives. The Decade's strategy states that the selected flagship initiatives will have the opportunity to receive finance for further scaling up (e.g. through developing funding mechanisms, or raising seed capital).

Table 9 **Examples of international financing sources for climate action on peatlands**

Sources of financing	Scope	Examples	Opportunities for peatlands
Global financing mechanisms	Low and middle-income countries	Green Climate Fund (GCF), Global Environmental Facility (GEF), Adaptation Fund, and others	Projects or programs with climate mitigation and/or adaptation goals for peatland landscapes. See e.g. a project in Malaysia financed by the GEF, and a project in Peru financed by the GCF.
REDD+ readiness funds and results-based payments (RBP)	Low and middle-income countries	Forest Carbon Partnership Facility (FCPF) & GFC REDD+	Inclusion of conservation or restoration of forested peatland ecosystems in national REDD+ programs. See e.g. Indonesia REDD-plus RBP for results period 2014–2016
Bilateral funds	Low and middle-income countries	Mitigation-focused funds from development cooperation budgets such us IKI, UK PACT, NICFI	Projects or programs with mitigation or adaptation goals for peatlands, depending on the objectives of each call. See e.g. the Global Peatlands Initiative project and this project in the Congo Basin peatlands, both financed by IKI.
Multilateral funds	Low and middle-income countries	NAMA Facility, NDC Partnership, etc.	Projects or programs with climate mitigation and/or adaptation goals on peatlands, depending on the objectives of each call.
Voluntary carbon market	All countries	Verified Carbon Standard (VCS), The REDD+ Environmental Excellence Standard (TREES), upcoming EU carbon removal certification framework	Carbon credits to finance the conservation and restoration of carbon stocks and sinks of natural systems, including avoided emissions from peatlands. E.g. the VCS approved REDD+ project in the Katingan-Mentaya peatland landscape.
Debt-for-nature swaps	Countries with a high foreign debt	No examples to date that would involve peatlands. But see e.g. the US Tropical Forest and Coral Reef Conservation Act	Inclusion of conservation actions as part of the commitments of the beneficiary countries.
Green bonds	All countries	The Indonesian Peat Bond	Integration of small local projects on peatlands into nation-scale portfolios/programs so they can reach the average value of issued green bonds.
Payment for ecosystem services (PES)	All countries	Payments for Ecosystem Services (PES) Pilot Research Project in the United Kingdom, and various other countries.	Inclusion and prioritization of peatlands in PES for watershed and biodiversity conservation, other water services and carbon sequestration.

Sources: **FAO & Wetlands International**. 2012. Peatlands - guidance for climate change mitigation through conservation, rehabilitation and sustainable use. Second edition. www.fao.org/3/an762e/an762e00.pdf

Avagyan, A., Karttunen, K., De Vit, C., Rioux, *J. 2015. Learning tool on Nationally Appropriate Mitigation Actions (NAMAs) in the agriculture, forestry and other land use (AFOLU) sector.* Rome, FAO. www.fao.org/3/i4642e/i4642e.pdf

Barbier, E.B. & Burgess, J.C. (eds). 2021. *Economics of Peatlands Conservation, Restoration, and Sustainable Management - A Policy Report for the Global Peatlands Initiative*. Nairobi, United Nations Environment Programme. https://wedocs.unep.org/bitstream/handle/20.500.11822/37262/PeatCRSM.pdf

UNFCCC 2022. *Introduction to climate finance.* Secretariat of the United Nations Framework Convention on Climate Change. Bonn, Germany. Cited 25 September 2022. https://unfccc.int/topics/climate-finance/the-big-picture/introduction-to-climate-finance

Despite many opportunities, there are also numerous challenges to finance conservation and restoration of peatlands. The financial risks of peatland projects are higher than those of other activities in the land sector. Most investment risks are related to land ownership and tenure. Peatland areas often have unclear borders and these landscapes can be prone to disturbance, such as fires and social unrest (see e.g. Puspitaloka et al., 2021). There is a lack of experience by the finance sector, decision makers and stakeholders in general on managing finance for peatlands. For example, 50 percent of the peatland-related stakeholders who participated in an FAO survey indicated that they were not aware of any financing mechanisms to carry out conservation, restoration, or sustainable management activities in peatlands (FAO, 2021).

Financial risks are frequently overlooked and a trial-and-error mode is often practiced. It is, however, important to identify from the outset the financial costs and benefits of the committed climate action. Participatory mapping of stakeholders, activities, issues and solutions can guide governments and investors to address some of the challenges. At the same time, long-term financial strategies must consider the high risks of climate inaction, which could lead to a loss of the total global economic value of around 10 percent by 2050 (Swiss Re Institute, 2021).

At the same time, long-term financial strategies must consider the high risks of climate inaction, which could lead to a loss of the total global economic value of around 10 percent by 2050.

When identifying investments in and establishing public policies and regulations for peatlands, it is important that the multiple stakeholders involved do not exclude or undervalue the ecosystem services that peatlands provide (Barbier and Burgess, eds., 2021). In this respect, PES could serve as an important incentive for peatland restoration and conservation. To support investment in and develop financial mechanisms directed at peatlands, cost-benefit analysis can support decision-making to compare restoration options or to prioritize sites (Ferré and Ortega, 2019).

Monitoring for transparency

Monitoring of climate finance needs to be part of the national transparency system under the UNFCCC framework (GIZ, 2014). Monitoring is important to ensure transparency, accountability and credibility of results, and to build confidence that resources are being effectively utilized. Specifically, monitoring the provision and receipt of financial flows, as well as the impacts of that investment can support reporting progress to the UNFCCC (donor countries), document experiences with the financial instruments used (recipient countries), and demonstrate the effectiveness of climate support (Singh *et al.*, 2016). Some challenges for monitoring climate finance are the multiple actors involved, the lack of an international definition of climate finance, the complexity to verify private finance, and the need to harmonize methodological and technical approaches for monitoring and reporting (GIZ, 2014).

© Greifswald Mire Centre/H. Joosten

©Convention on Wetlands/Maris Pärn

Conclusions

©Convention on Wetlands/Maris Pärn

Conclusions

Peatlands should be seen as sleeping bombs, whose risks should be integrated into global, regional and national policies to avoid them exploding. The majority of peatlands worldwide are still untouched and they should remain that way now and in the future to secure their immense carbon stocks and to maintain their significant adaptive capacity to the changing climate.

It is estimated that only 15 percent of the world's peatlands are currently drained and degraded, but this small proportion is responsible for GHG emissions larger than those of all of Africa or South America, and larger than those of international aviation and shipping sectors (Our World in Data, 2022). Emissions from degrading peatlands may persist until their peat layers are completely depleted (i.e. decades or even hundreds of years). This illustrates the immense danger threatening the still undrained 85 percent of peatlands globally.

Key lessons from countries' experience

Several types of land uses and multiple interest groups are situated across peatland landscapes with a large number and diversity of stakeholders. Lessons from countries' NDC processes show that broad and meaningful stakeholder engagement – especially with local communities – through inclusive and transparent consultations combined with knowledge exchange can support the design and implementation of new policies. Inclusion of stakeholders from the academic community can help to ensure that climate commitments and plans are in line with the latest scientific evidence. The inclusion of both scientific and traditional knowledge may support the sustainability of the actions and increase credibility for investors. Striving to build an attitude of trust towards the public sector mandated with NDC enhancement helps to secure the implementation of planned activities. The involvement of academia, Indigenous and local communities and private sector can also boost the development of innovative solutions that take into account local needs as well as the feasibility of actions at a larger landscape scale.

It is important to align NDCs with LTSs and other national strategies to enable the effectiveness and efficiency of any planned activities, to reduce duplication (i.e. expenses) and to facilitate measurement and reporting. Realistic planning will allow successful implementation of climate action. In countries that are still at the early stages of mapping and assessment, it may be useful to start on a small scale to prove effectiveness, then monitor, evaluate and adapt, and finally to scale up.

Several countries have taken significant steps to enhance their climate ambition, by setting clear targets and/or priority actions in their NDCs – or other national climate laws and plans – to protect, restore and sustainably manage their peatlands. Their experience and lessons learned can support other countries to plan their climate strategies.

Opportunities

In countries where peatlands are still largely unknown, efforts must be made to identify peatlands to be able to include them in land use planning. For these countries, the inclusion of peatlands in the NDCs relies on requesting technical and financial support for peatland inventory, capacity development and implementing actions to conserve and protect peatlands and address climate change.

Peatlands that are not mapped or monitored, are peatlands without apparent value. These are prone to degradation as development plans advance through business as usual as population grows. Peatlands should be recognized and valued for their ability to limit global warming and to ensure the resilience of the wider ecosystem and local people in the midst of severe and recurrent disasters.

Peatland action is one of the most cost-effective climate actions that peatland-rich countries can benefit from. The international

community should embrace and strengthen its support to developing countries to help them protect the invaluable ecosystem services that peatlands render to the entire planet, while at the same time satisfying national development needs. Any planned policies and activities must strive to contribute and promote climate justice. As such, the people and communities most vulnerable to the impacts of climate change should be empowered and fully involved in the planning and implementation process to achieve the long-term resilience of peatland landscapes.

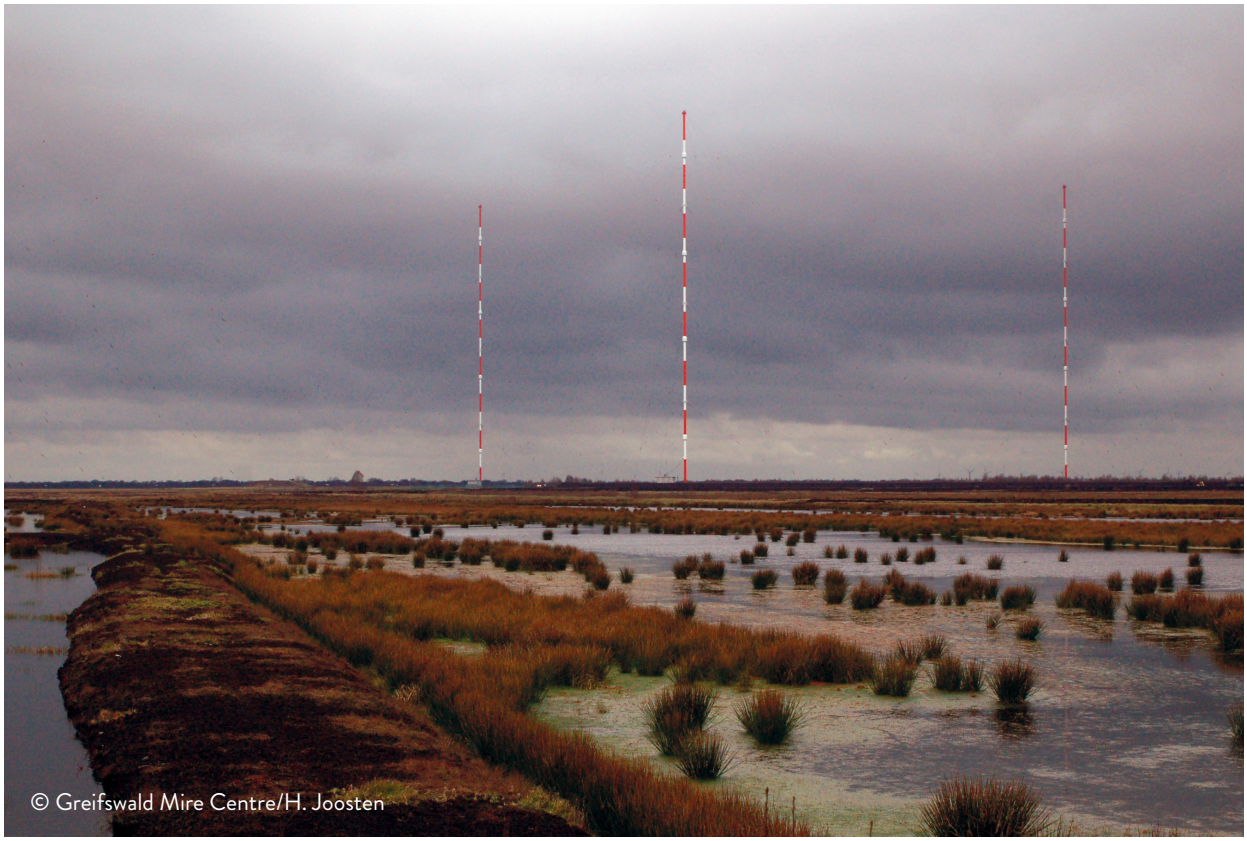
In some regions, peatlands have become major sources of GHGs. In other regions, they are under imminent risk of degradation. They threaten to push climate change beyond the bounds of acceptability. Humanity still has an opportunity to turn the tide, by keeping all wet peatlands wet and by rewetting the peatlands that are drained. Actions should, however, advance rapidly within the next decade.

There are no easy solutions, but the central message is clear: peatlands must be wet to support the climate, the land and the people. The goals of the Paris Agreement cannot be reached without peatlands. The large pool of knowledge already available, new monitoring technologies and the clear need for bold and urgent climate action shine the light for a present and future where healthy peatlands are conserved and degraded ones are fully and effectively rewetted. We hope this brief will support this path and will offer the reader a useful tool set that will be improved and updated as more experiences on peatland climate action are gathered.

Join the peat movement

The Global Peatlands Initiative (GPI) is a network of over 48 national and international actors and four countries (Democratic Republic of the Congo, Indonesia, Peru and Republic of the Congo). GPI welcomes other countries and partners to join for maintaining peatlands as the World's major organic carbon stock.

This is the first of three knowledge products that will be developed on peatlands and climate commitments under the Global Peatlands Initiative Project. The second product will focus on the implementation of climate action and peatlands covering implementation instruments, regulatory frameworks, capacities, monitoring and reporting, and next steps. The third product will present the results of an analysis of the role of wetlands in achieving national climate change mitigation and adaptation goals. It will also identify the challenges behind and opportunities for mainstreaming peatlands, mangroves and seagrasses into enhanced NDC targets and measures. FAO welcomes all interested in joining events and efforts to support the work for NDCs. Please do get in contact through: Peatlands@fao.org.


© Greifswald Mire Centre/H. Joosten

References

Adinugroho, W., Suryadiputra, N., Saharjo, B. & Siboro, L. 2005. *Manual for the control of fire in peatlands and peatland forest.* 979-99373-7-X

Asian Development Bank. 2017. *Assessment Report 2017. Strategic planning for peatlands in Mongolia*. Asian Development Bank Technical Assistance TA-8802.

Avagyan, A., Karttunen, K., DeVit, C., Rioux, J. 2015. *Learning tool on Nationally Appropriate Mitigation Actions (NAMAs) in the agriculture, forestry and other land use (AFOLU) sector.* Rome, FAO. www.fao.org/3/i4642e/i4642e.pdf

Barbier, E.B. & Burgess, J.C. (eds). 2021. *Economics of Peatlands Conservation, Restoration, and Sustainable Management - A Policy Report for the Global Peatlands Initiative*. Nairobi, United Nations Environment Programme. https://wedocs.unep.org/bitstream/handle/20.500.11822/37262/PeatCRSM.pdf

Bhomia, R.K. & Murdiyarso, D. 2021. *Effective monitoring and management of peatland restoration*. Working Paper 270. Bogor, Indonesia, CIFOR. www.cifor.org/publications/pdf_files/wpapers/wp270bhomia.pdf

Carlson, K.M., Goodman, L.K. & May-Tobin, C.C. 2015. Modeling relationships between water table depth and peat soil carbon loss in Southeast Asian plantations. *Environmental Research Letters*, 10: 074006.

Climate Watch. 2020. Climate Watch LTS explore. In: *Climate Watch*. Washington, DC, World Resources Institute. Cited 30 August 2022. www.climatewatchdata.org/lts-explore

Cole, L. 2017. Rwanda adds to energy mix with first peat-fired power plant in Africa. In: *The Conversation*. Melbourne, Australia. Cited 10 November 2022. https://theconversation.com/rwanda-adds-to-energy-mix-with-first-peat-fired-power-plant-in-africa-74380

Convention on Wetlands. 2021a. *Global guidelines for peatland rewetting and restoration*. Ramsar Technical Report No. 11. Gland, Switzerland, Secretariat of the Convention on Wetlands. www.ramsar.org/sites/default/files/documents/library/rtr11_peatland_rewetting_restoration_e.pdf Also available in French & Spanish

Convention on Wetlands. 2021b. *Practical peatland restoration*. Briefing Note No. 11. Gland, Switzerland, Secretariat of the Convention on Wetlands. www.ramsar.org/sites/default/files/documents/library/bn11_practical_peatland_restoration_e.pdf Also available in French & Spanish

Convention on Wetlands. 2021c. *Restoring drained peatlands: A necessary step to achieve global climate goals.* Ramsar Policy Brief No. 5. Gland, Switzerland, Secretariat of the Convention on Wetlands. www.ramsar.org/sites/default/files/documents/library/rpb5_restoring_drained_peatlands_e.pdfpeatlands_e.pdf Also available in French & Spanish

Convention on Wetlands. 2021d. *Transforming agriculture to sustain people and wetlands.* Ramsar Policy Brief No. 6. Gland, Switzerland, Secretariat of the Convention on Wetlands. www.ramsar.org/sites/default/files/documents/library/rpb6_agriculture_e.pdf

Convention on Wetlands. 2021e. *Wetlands and agriculture: impacts of farming practices and pathways to sustainability.* Ramsar Policy Brief No. 13. Gland, Switzerland, Secretariat of the Convention on Wetlands. www.ramsar.org/sites/default/files/documents/library/bn13_agriculture_e.pdf

Couwenberg, J., Baumann, M., Lamkowski, P. & Joosten, H. 2022. From genes to landscapes: Pattern formation and self-regulation in raised bogs with an example from Tierra del Fuego. *Ecosphere,* 13: e4031.

Crumpler, K., Meybeck, A., Federici, S., Salvatore, M., Damen, B., Gagliardi, G., Dasgupta, S., Bloise, M., Wolf, J. & Bernoux, M. 2020. *A common framework for agriculture and land use in the nationally determined contributions.* Environment and Natural Resources Management Working Papers No. 85. Rome, FAO. https://doi.org/10.4060/cb1589en

Crumpler, K., Abi Khalil, R., Tanganelli, E., Rai, N., Roffredi, L., Meybeck, A., Umulisa, V., Wolf, J. & Bernoux, M. 2021. (Interim) *Global update report: Agriculture, forestry and fisheries in the Nationally Determined Contributions.* Environment and Natural Resources Management Working Paper No. 91. Rome, FAO. https://doi.org/10.4060/cb7442en

Dargie, G.C., Lawson, I.T., Rayden, T.J., Miles, L., Mitchard, E.T.A., Page, S.E., Bocko, Y.E., Ifo, S.A. & Lewis, S.L. 2018. Congo Basin peatlands: threats and conservation priorities. *Mitigation and adaptation Strategies for Global Change,* 24: 69–686. https://doi.org/10.1007/s11027-017-9774-8

Dennis, R. 1999. *A Review of Fire Projects in Indonesia (1982-1998).* Bogor, Indonesia, Centre for International Forestry Research. https://doi.org/10.17528/cifor/000564

Erkens, G., Van der Meulen, M.J. & Middelkoop, H. 2016. Double trouble: subsidence and CO_2 respiration due to 1,000 years of Dutch coastal peatlands cultivation. *Hydrogeology Journal,*24: 551–568.

European Comission. 2022. *Carbon leakage*. Brussels, Directorate-General for Climate Action, European Commission. Cited 20 August 2022. https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/free-allocation/carbon-leakage_en

Evans, C.D., Williamson, J.M., Kacaribu, F., Irawan, D., Suardiwerianto, Y., Hidayat, M. F., Laurén, A. & Page, S.E. 2019. Rates and spatial variability of peat subsidence in Acacia plantation and forest landscapes in Sumatra, Indonesia. *Geoderma,* 338(August 2018): 410–421. https://doi.org/10.1016/j.geoderma.2018.12.028

Evans, C.D., Peacock, M., Baird, A.J., Artz, R.R.E., Burden, A., Callaghan, N., Chapman, P.J., Cooper, H. M., Coyle, M., Craig, E., Cumming, A., Dixon, S., Gauci, V., Grayson, R. P., Helfter, C., Heppell, C.M., Holden, J., Jones, D.L., Kaduk, J., Levy, P., Matthews, R., McNamara, N.P., Misselbrook, T., Oakley, S., Page, S.E., Rayment, M., Ridley, L.M., Stanley, K.M., Williamson, J.L., Worrall, F. & Morrison, R. 2021. Overriding water table control on managed peatland greenhouse gas emissions. *Nature*, 593: 547-552. https://doi.org/10.1038/s41586-021-03523-1

Ewert, S. & Abel, S. 2021. *The transition to sustainable life on wetlands: how the sustainable use of peatlands appears on the political agenda*. Basel, Switzerland, MDPI. www.mdpi.com/books/pdfdownload/article/3815

FAO. 2015a. *Restoration of overgrazed páramo grasslands for hydrological benefits*. Practice case I4430E/1/02.15. www.fao.org/3/i4430e/i4430e.pdf

FAO. 2015b. *Beje, aquaculture and inland fishery in tropical peatland.* Practice case I4423E/1/02.15. www.fao.org/3/i4423e/i4423e.pdf

FAO. 2017. *Voluntary guidelines on national forest monitoring*. Rome. www.fao.org/3/i6767e/i6767e.pdf

FAO. 2020. *Peatland mapping and monitoring Recommendations and technical overview*. Rome. http://www.fao.org/3/ca8200en/ca8200en.pdf

FAO. 2021. *Needs and knowledge gaps on peatlands for climate action. Global survey results May 2020 – March 2021.* Technical report. Rome. www.fao.org/3/cb8252en/cb8252en.pdf

FAO. 2022. *L'agriculture intelligente face au climat*. Rome. Cited 30 August 2022. www.fao.org/climate-smart-agriculture/policies-planning/fr

FAO, Alliance of Biodiversity International & CIAT. 2021. *Indigenous Peoples' food systems: Insights on sustainability and resilience in the front line of climate change*. Rome. https://doi.org/10.4060/cb5131en

FAO & ITPS. 2021. *Recarbonizing global soils: A technical manual of recommended management practices.* Volume 5: Forestry, Wetlands and Urban Soils -Practices overview. Rome, FAO and Intergovernmental Technical Panel on Soils. https://doi.org/10.4060/cb6606en

Ferré, M. & Ortega, M. 2019. *A User Guide for Valuing the Benefits of Peatland Restoration.* University of Leeds: integrated Catchment Solution Programme (iCASP), Leeds. https://doi.org/10.5518/100/9

Finlex. 2011. *Lainsäädäntö, Säädökset alkuperäisinä*, 2011, 379/2011. Finlex. Helsinki, Finland. Cited 25 September 2022. https://finlex.fi/fi/laki/alkup/2011/20110379

Ganz, D. & Moore, P. 2002. Living with fire: summary of Communities in flames international conference. In: FAO, eds. *Communities in Flames: Proceedings of an International Conference on Community Involvement in Fire Management.* FAO & FireFight Southeast Asia. Bangkok. Cited 20 August 2022. www.fao.org/3/ac798e/ac798e05.htm#bm05

GEF. 2019. *Advances in Blended Finance. GEF's Solutions to Protect the Global Environment*. www.thegef.org/sites/default/files/publications/gef_advances_blended_finance_201911.pdf

Gewin, V. 2020. How peat could protect the planet. *Nature*, 578 : 204–208. doi: https://doi.org/10.1038/d41586-020-00355-3

Giesen, W. & Sari, E. N. 2018. *Tropical Peatland Restoration Report: the Indonesian case*. 10.13140/RG.2.2.30049.40808.

GIZ. 2014. *Measuring, Reporting and Verifying Climate Finance International state of play and future perspectives.* Eschborn, Germany, Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH. https://transparency-partnership.net/sites/default/files/giz2014-en-climate-finance-mrv.pdf

GIZ. 2019. *Options for financing emission avoidance from drained peatlands in the Nile Basin: Discussion paper.* NBI Technical Reports: Wetlands and Biodiversity series. Cited 30 August 2022. www.nilebasin.org/index.php/information-hub/technical-documents/84-options-for-financing-emission-avoidance-from-drained-peatlands-in-the-nile-basin/file

Goldammer, J.G., Frost, P.G.H., Jurvélius, M., Kamminga, E.M., Kruger, T., Moody, S.I. & Pogeyed, M. 2002. Community participation in integrated forest fire management: experiences from Africa, Asia and Europe. In: FAO, eds. *Communities in Flames: Proceedings of an International Conference on Community Involvement in Fire Management*. Bangkok, FAO & FireFight Southeast Asia. www.fao.org/3/ac798e/ac798e09.htm#bm9

Green Climate Fund. 2015. *FP001 Building the Resilience of Wetlands in the Province of Datem del Marañón, Peru.* Incheon, Republic of Korea. Cited 30 August 2022. www.greenclimate.fund/project/fp001

Greifswald Mire Centre. 2022. Database of Potential Paludiculture Plants. Cited 30 August 2022. www.greifswaldmoor.de/dppp-109.html

Günther, A., Barthelmes, A., Huth, V., Joosten, H., Jurasinski, G., Koebsch, F. & Couwenberg, J. 2020. Prompt rewetting of drained peatlands reduces climate warming despite methane emissions. *Nature Communications*, 11, 1644. www.nature.com/articles/s41467-020-15499-z.pdf

Harris, L.I., Richardson, K., Bona, K.A., Davidson, S.J., Finkelstein, S.A., Garneau, M., McLaughlin, J., Nwaishi, F., Olefeldt, D., Packalen, M., Roulet, N.T., Southee, F.M., Strack, M., Webster, K.L., Wilkinson, S.L. & Ray, J.C. 2022. The essential carbon service provided by northern peatlands. *Frontiers in Ecology and the Environment*, 20: 222-230.

Hergoualc'h, K., Atmadja, S., Carmenta, R., Martius, C., Murdiyarso, D. & Purnomo, H. 2018. *Managing peatlands in Indonesia: Challenges and opportunities for local and global communities*. Info Brief. No. 205. Bogor, Indonesia, CIFOR. DOI: 10.17528/cifor/006449

Herold, B. 2012. *Neues Leben in alten Mooren, Brutvögel wiedervernässter Flusstalmoore*. 200 pp. Bern, Haupt & Zurich, Switzerland, Bristol-Schriftenreihe.

Hincks, J. 2021. *How Blended Finance Is Protecting Indonesia's Forests and Empowering Women at the Same Time*. Cited 7 September 2022. https://indonesia.un.org/en/130274-how-blended-finance-protecting-indonesias-forests-and-empowering-women-same-time

Hirano, T., Kusin, K., Limin, S. & Osaki, M. 2014. Carbon dioxide emissions through oxidative peat decomposition on a burnt tropical peatland. *Global Change Biology*, 20: 555–65. https:// doi. org/10. 1111/ gcb. 12296

Hooijer, A., Vernimmen, R., Visser, M. & Mawdsley, N. 2015. *Flooding projections from elevation and subsidence models for oil palm plantations in the Rajang Delta peatlands, Sarawak, Malaysia*. 76 pp. Deltares report 1207384.

Hosen, N., Hitoshi, N. & Hamzah, A. 2020. Adaptation to Climate Change: Does Traditional Ecological Knowledge Hold the Key? *Sustainability*, 12(2):676. https://doi.org/10.3390/su12020676

IPCC. 2014. 2013 *Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands.* 1–55 pp. Geneva, Switzerland, Intergovernmental Panel on Climate Change. www.ipcc.ch/site/assets/uploads/2018/03/Wetlands_Supplement_Entire_Report.pdf

IPCC. 2018. *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Geneva, Switzerland, World Meteorological Organization. www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_Low_Res.pdf

IPCC. 2022. Figure SPM.4 from: Summary for Policymakers. In: P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, eds. *Climate Change 2022: Mitigation of Climate Change*. *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, UK & New York, USA, Cambridge University Press. DOI: 10.1017/9781009157926.001

IUCN. 2017. *Peatlands and climate change*. Issues brief. Gland, Switzerland. www.iucn.org/resources/issues-brief/peatlands-and-climate-change

Joosten, H. 2022. Moor muss nass. Wiedervernässung vorantreiben, Torfabbau verhindern. In: K., Wiegandt, eds. *Drei Grad mehr – Ein Blick in die drohende Heißzeit und wie uns die Natur helfen kann sie zu verhindern*. pp. 209-232. Munich, Germany, Oekom.

Joosten, H. & Clarke, D. 2002. *Wise Use of Mires and Peatlands. Background and principles including a framework for decision-making*. International Mire Conservation Group and International Peat Society.

Joosten, H. & Couwenberg, J. 2008. Peatlands and carbon. In: F., Parish, A., Sirin, D., Charman, H., Joosten, T., Minayeva & M., Silvius, eds. *Assessment on peatlands, biodiversity and climate change*, pp. 99–117. Kuala Lumpur, Global Environment Centre & Wageningen, Wetlands International.

Joosten, H., Sirin, A, Couwenberg, J., Laine, J. & Smith, P. 2016. The role of peatlands in climate regulation. In: A., Bonn, T., Allott, M., Evans, H., Joosten & R., Stoneman, eds. *Peatland restoration and ecosystem services: Science, policy and practice*, pp. 63–76. Cambridge, UK, Cambridge University Press & British Ecological Society.

Jurasinski, G., Günther, A., Huth, V., Couwenberg, J. & Glatzel, S. 2016. Greenhouse gas emissions. In: W., Wichtmann, C., Schröder & H., Joosten, eds. *Paludiculture – productive use of wet peatlands*. pp. 79-93. Stuttgart, Germany, Schweizerbart Science Publishers.

Kieft, J., Smith, T., Someshwar, S. & Boer, R. 2016. Towards Anticipatory Management of Peat Fires to Enhance Local Resilience and Reduce Natural Capital Depletion. In: F.G. Renaud, K. Sudmeier-Rieux, M. Estrella & U. Nehren, eds. *Ecosystem-Based Disaster Risk Reduction and Adaptation in Practice*. pp. 361–377. Vol. 42. Advances in Natural and Technological Hazards Research. Cham, Springer International Publishing. https://doi.org/10.1007/978-3-319-43633-3_16

Kiely, L., Spracklen, D.V., Arnold, S.R., Papargyropoulou, E., Conibear, L., Wiedinmyer, C., Knote, C. & Adrianto, H.A. 2021. Assessing costs of Indonesian fires and the benefits of restoring peatland. *Nature Communications,* 12(1): 7044. https://doi.org/10.1038/s41467-021-27353-x

Koplitz, S.N., Mickley, L.J., Marlier, M.E., Buonocore, J.J., Kim, P.S., Liu, T., Sulprizio, M.P., DeFries, R.S., Jacob, D.J., Schwartz, J., Pongsiri, M. & Myers, S.S. 2016. *Public health impacts of the severe haze in Equatorial Asia in September–October 2015: demonstration of a new framework for informing fire management strategies to reduce downwind smoke exposure*. Environmental Research Letters, 11(9): 94023. https://doi.org/10.1088/1748-9326/11/9/094023

Krebs, M., Kaffke, A., de Klerk, P., Matchutadze, I. & Joosten, H. 2009. *A future for Ispani 2 (Kolkheti, Georgia) and adjacent lands*. International Mire Conservation Group Newsletter. 2009/2: 3-14. Cited 30 August 2022. www.researchgate.net/publication/259692606_a_future_for_ispani_2_kolkheti_georgia_and_adjacent_lands

Leifeld, J., Wüst-Galley, C. & Page, S. 2019. Intact and managed peatland soils as a source and sink of GHGs from 1850 to 2100. *Nature Climate Change,* 9: 945–947. www.nature.com/articles/s41558-019-0615-5

Maldonado Fonkén, M. 2014. An introduction to the bofedales of the Peruvian High Andes. *Mires and Peat*, 15 (05): 1–13.

Ministry of Environment & Forestry of the Republic of Indonesia. 2018. *Managing peatlands to cope with climate change: Indonesia's experience.* Jakarta. https://wedocs.unep.org/bitstream/handle/20.500.11822/25352/managing_peatlands_indonesia.pdf?sequence=1&isallowed=y

Mongabay. 2021. *Carbon and communities: The future of the Congo Basin peatlands*. https://news.mongabay.com/2021/12/carbon-and-communities-the-future-of-the-congo-basin-peatlands/

Moxey, A., Smyth, M., Taylor, E. & Williams, A. 2021. *Barriers and opportunities facing the UK Peatland Code: A case-study of blended green finance.* Land Use Policy, Volume 108,2021, 105594. https://doi.org/10.1016/j.landusepol.2021.105594

Mrotzek, A., Michaelis, D., Günther, A., Wrage-Mönnig, N. & Couwenberg, J. 2020. Mass balances of a drained and a rewetted peatland: on former losses and recent gains. *Soil Systems*, 4, 16: 1-14. www.mdpi.com/2571-8789/4/1/16

Mugerwa, T., Rwabuhungu, D.E., Ehinola, O.A., Uwanyirigira, J. & Muyizere, D. 2019. Rwanda peat deposits: An alternative to energy sources. *Energy Reports,* 5: 1151–1155.

NDC Partnership. 2021. *Workshop report. Good Practices in NDC Updates and Implementation: Challenges and Lessons Learned from Asia, the Middle East, and North Africa*. https://unfccc.int/sites/default/files/resource/NDC_Final%20Workshop%20Report%20%281%29.pdf

Nugent, K.A., Strachan, I.B., Strack, M., Roulet, N.T. & Rochefort, L. 2018. Multi-year net ecosystem carbon balance of a restored peatland reveals a return to a carbon sink. *Global Change Biology*, 24: 5751-5768. https://onlinelibrary.wiley.com/doi/epdf/10.1111/gcb.14449

Our World in Data. 2022. *CO_2 emissions*. Our World in Data, Global Change Data Lab. UK. Cited 20 August 2022. https://ourworldindata.org/co2-emissions

Page, S.E., Mishra, S., Agus, F., Anshari, G., Dargie, G., Evers, S., Jauhiainen, J., Jaya, A., Jovani-Sancho, A. J., Laurén, A., Sjogersten, S., Suspense, I.A., Wijedasa, L.S. & Evans, C. 2022. Antropogenic impacts on lowland tropical peatland biogeochemistry. *Nature Reviews Earth & Environment*, 3, 426–443. https://doi.org/10.1038/s43017-022-00289-6

Palmer, J. 2022. *Traditional knowledge guides protection of planetary health in Finland*. Mongabay, 31 March 2022. Cited 1 August 2022. https://news.mongabay.com/2022/03/traditional-knowledge-guides-protection-of-planetary-health-in-finland

Pan, X., Chin, M., Ichoku, C.M. & Field, R.D. 2018. Connecting Indonesian Fires and Drought With the Type of El Niño and Phase of the Indian Ocean Dipole During 1979-2016. *Journal of Geophysical Research: Atmospheres*. https://doi.org/10.1029/2018jd028402

Peacock, M., Audet, J., Bastviken, D., Futter, M.N., Gauci, V., Grinham, A., Harrison, J.A., Kent, M.S., Kosten, S., Lovelock, C.E., Veraart, A.J. & Evans, C.D. 2021. Global importance of methane emissions from drainage ditches and canals. *Environmental Research Letters,* 16 044010. https://doi.org/10.1088/1748-9326/abeb36

Puspitaloka, D., Yeon-Su, K., Purnomo, H. & Fulé, P. 2021**.** Analysis of challenges, costs, and governance alternative for peatland restoration in Central Kalimantan, Indonesia. *Trees, Forests and People,* 6. https://doi.org/10.1016/j.tfp.2021.100131

Rooney, R.C., Bayley, S.E. & Schindler, D.W. 2012. Oil sands mining and reclamation cause massive loss of peatland and stored carbon. *Proceedings of the National Academy of Sciences of the United States of America*, 109: 4933-4937. www.pnas.org/doi/10.1073/pnas.1117693108

Sari, A., Dohong, A., Wardhana, B. 2020. Innovative Financing for Peatland Restoration in Indonesia. In: R., Djalante, J., Jupesta, E., Aldrian, eds. *Climate Change Research, Policy and Actions in Indonesia. Springer Climate.* Springer, Cham. https://doi.org/10.1007/978-3-030-55536-8_12

Schiettecatte, L-S., Crumpler, K., Rams-Beltrán, E., Nuutinen, M., Joosten, H., Elshehawi, S., Guerrero-Machado, D., Dionisio, D., & Bernoux, M. 2022. *Wetlands in climate commitments. Preliminary results*. Rome, FAO. www.fao.org/3/cc2865en/cc2865en.pdf

SEEA. 2022. *Ecosystem Accounting. System of Environmental-Economic Accounting (SEEA*). United Nations. Cited 25 September 2022. https://seea.un.org/ecosystem-accounting

Singh, N., Finnegan J., & Levin, K. 2016. *MRV 101: Understanding measurement, reporting, and verification of climate change mitigation*. Working Paper. Washington, DC, World Resources Institute. https://transparency-partnership.net/sites/default/files/mrv_101_0.pdf

Simorangkir, D. 2006. Fire use: Is it really the cheaper land preparation method for large-scale plantations? *Mitigation and Adaptation Strategies for Global Change*, 12(1): 147–164. https://doi.org/10.1007/s11027-006-9049-2

Sobrevila, C. 2008. *The Role of Indigenous Peoples in Biodiversity Conservation: The Natural but Often Forgotten Partners.* The World Bank. Washington, DC. https://documents1.worldbank.org/curated/en/995271468177530126/f/443000wp0box321onservation01public1.pdf

Strack, M., Davidson, S.J., Hirano, T., Dunn, C. & Davidson, S.J. 2022. *The potential of peatlands as Nature - Based Climate Solutions.* Current Climate Change Reports (0123456789). https://doi.org/10.1007/s40641-022-00183-9

Succow, M. & Joosten, H. 2001. *Landschaftsökologische Moorkunde. E. Schweizerbart'sche Verlagsbuchhandlung. Nägele u*. 623 pp. Stuttgart, Germany, Obermiller.

Suwardi, M.B., Sumawinata, B. & Sandrawati, A. 2005. Sejarah Pengelolaan Lahan Gambut di Indonesia. *Gakuryoku*, 11(2), 120–126.

Swiss Re Institute. 2021. *The economics of climate change: no action not an option*. www.swissre.com/institute/research/topics-and-risk-dialogues/climate-and-natural-catastrophe-risk/expertise-publication-economics-of-climate-change.html

Tan, Z.D., Carrasco, L.R., Sutikno, S. & Taylor, D. 2022. Peatland restoration as an affordable nature-based climate solution with fire reduction and conservation co-benefits in Indonesia. *Environmental research letters*, 17:6. https://iopscience.iop.org/article/10.1088/1748-9326/ac6f6e

Temmink, R.J.M., Lamers, L.P.M., Angelini, C., Bouma, T.J., Fritz, C., Van de Koppel, J., Lexmond, R, Rietkerk, M., Silliman, B.R., Joosten, H. & Van der Heide, T. 2022. Recovering wetland biogeomorphic feedbacks to restore the world's biotic carbon hotspots. *Science,* 376, eabn1479. DOI: 10.1126/science.abn1479

Trepel, M. 2010. Assessing the cost-effectiveness of the water purification function of wetlands for environmental planning. *Ecological Complexity,* 7: 320–326.

Turetsky, M., Benscoter, B., Page, S., Rein, G., Van der Werf, G.R. & Watts, A. 2015. Global vulnerability of peatlands to fire and carbon loss. *Nature Geoscience*, 8, 11–14. https://doi.org/10.1038/ngeo2325

UNDP. 2017. *Aligning nationally determined contributions and Sustainable Development Goals: lessons learned and practical guidance*. www.undp.org/publications/ndcs-and-sdgs

UNEP. 2019. *UNEA resolution on nature-based solutions for supporting sustainable development*. UNEP/EA.5/Res.5. Nairobi, UNEP. https://wedocs.unep.org/bitstream/handle/20.500.11822/39752/k2200677%20-%20unep-ea.5-res.5%20-%20advance.pdf?sequence=1&isallowed=y

UNFCCC. 2021a. *Glasgow Climate Pact.* Decision -/CMA.3. https://unfccc.int/sites/default/files/resource/cma3_auv_2_cover%2520decision.pdf

UNFCCC. 2021b. *Nationally determined contributions under the Paris Agreement*. Revised synthesis report by the secretariat. https://unfccc.int/sites/default/files/resource/cma2021_08r01_E.pdf

UNFCCC. 2022a. *Communication of long-term strategies*. Cited 25 September 2022. https://unfccc.int/process/the-paris-agreement/long-term-strategies

UNFCCC. 2022b. *Reference Manual for the Enhanced Transparency Framework under the Paris Agreement Understanding the enhanced transparency framework and its linkages*. Version 2. https://unfccc.int/sites/default/files/resource/v2_ETFreferencemanual.pdf

Virapongse, A., Endressc, B.A., Gilmore, M.P., Horne, C. & Romulo, C. 2017. *Ecology, livelihoods, and management of the Mauritia flexuosa palm in South America*. Global Ecology and Conservation, 10: 70–92. ISSN 2351-9894. https://doi.org/10.1016/j.gecco.2016.12.005.

Visit Finland. 2022. *Nature in Finland.* Business Finland Oy, Visit Finland. Helsinki, Finland. Cited 25 September 2022. www.visitfinland.com/en/places-to-go/nature

Wakhid, N., Hirano, T., Okimoto, Y., Nurzakiah, S. & Nursyamsi, D. 2017. Soil carbon dioxide emissions from a rubber plantation on tropical peat. *Science of the Total Environment,* 581: 857–65. https://doi.org/10.1016/j.scitotenv.2017.01.035

Wilson, D. Blain, D., Couwenberg, J., Evans, C.D., Murdiyarso, D., Page, S.E., Renou-Wilson, F., Rieley, J.O., Sirin, Strack, A. M. & Tuittila, E.-S. 2016. Greenhouse gas emission factors associated with rewetting of organic soils. *Mires and Peat*, 17, Article 04, 1–28. http://mires-and-peat.net/ pages/volumes/map17/map1704.php

Worrall, F., Howden, N.J.K., Burt, T.P., Rico-Ramirez, M.A. & Kohler, T. 2022. Local climate impacts from ongoing restoration of a peatland. *Hydrological Processes,* 36: e14496.

WRI. 2016. E*xamining the Alignment Between the intended nationally determined contributions and Sustainable Development Goals, working paper*. https://www.wri.org/sites/default/files/WRI_INDCs_v5.pdf

WWF. 2017. *Forests ablaze: Causes and effects of global forest fires*. Berlin, WWF Germany. www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/WWF-Study-Forests-Ablaze.pdf

Xu, J., Morris, P.J., Liu, J. & Holden, J. 2018. Hotspots of peatland-derived potable water use identified by global analysis. *Nature Sustainability*, 1 (5). pp. 246-253. https://doi.org/10.1038/s41893-018-0064-6

Zeitz, J. 2016. Drainage induced peat degradation processes & Impact of drainage on productivity. In: W., Wichtmann, C., Schröder & H., Joosten, eds. *Paludiculture – productive use of wet peatlands*, pp. 7–13. Stuttgart, Schweizerbart Science Publishers.

Peatlands and climate planning

Part 1: Peatlands and climate commitments

Peatlands contain huge carbon stocks yet they cover only 3 percent of the world's land area. Improved peatland management provides climate change mitigation and adaptation opportunities. Peatland conservation and restoration also secures ecosystem services that support adaptive capacity and resilience.

This brief is part of the Global Peatlands Initiative's work to support national governments in the process of enhancing their climate commitments, such as the nationally determined contributions as well as the long-term strategies through the inclusion of climate action on peatlands. Including peatlands under various sectors' emission reduction and adaptation targets, such as in the agriculture, forestry and other land use sector, the energy sector, can greatly contribute to reaching the goals set under the Paris Agreement.

This is the first of a package of products to inform key stakeholders on practical and applicable means. The authors aim to motivate national agencies to include peatland considerations into national legislative, regulatory, planning and monitoring processes to ensure climate action implementation on these areas.

Global Peatlands Initiative

GREIFSWALD MIRE CENTRE

IKI INTERNATIONAL CLIMATE INITIATIVE

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the German Bundestag

ISBN 978-92-5-137182-4

9 789251 371824

CC2895EN/1/11.22